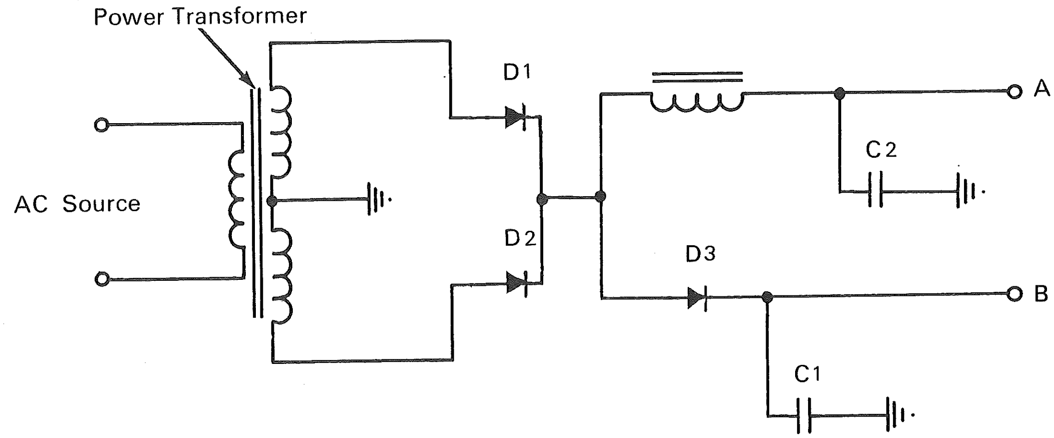
January 1966 Brief 66-10002

NASA TECH BRIEF

Dual-Voltage Power Supply Has Increased Efficiency



The problem: To design an efficient circuit that will provide two different dc output voltages from an ac source. Conventional circuits require either a precisely tapped transformer with a separate rectifier and filter for each voltage output, or dropping resistors, which waste power and result in poor regulation.

The solution: A simple circuit employing a full-wave rectifier connected to two passive branches from which the separate dc voltages are taken.

How it's done: The primary winding of the power transformer is connected to the ac source, and the secondary winding is connected to the full-wave rectifier consisting of diodes D1 and D2. The unfiltered output from the full-wave rectifier is fed in parallel to a conventional choke-input filter branch and a diode-capacitor branch. The diode, D3, in this branch conducts on the peaks of the full-wave rectifier current and charges capacitor C1 to the peak voltage across one half of the secondary winding of the power transformer. The voltage at terminal A will be approximately 40% greater than at terminal B. The required peak inverse-voltage rating of diode D3 is only one-half the peak voltage across the full secondary winding of the transformer.

Notes:

1. For maximum voltage output at terminal A, a high-conductance semiconductor diode should be used in the branch.
2. The ratio of the output voltages may be varied by proper choice of component values.
3. The outputs have low ripple and good voltage regulation.
4. This circuit can be used in lieu of relatively complex and expensive voltage regulators to supply dual voltages in applications not requiring precise voltage regulation.

(continued overleaf)

5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B66-10002

Patent status: NASA encourages the commercial use of this invention. It was invented by a NASA employee, and U.S. Patent No. 3,053,991 has been issued to him. Inquiries about obtaining license rights for its commercial development should be addressed to the inventor, Mr. John C. Sturman, NASA, Lewis Research Center, 21000 Brookpark Road, Cleveland, Ohio, 44135

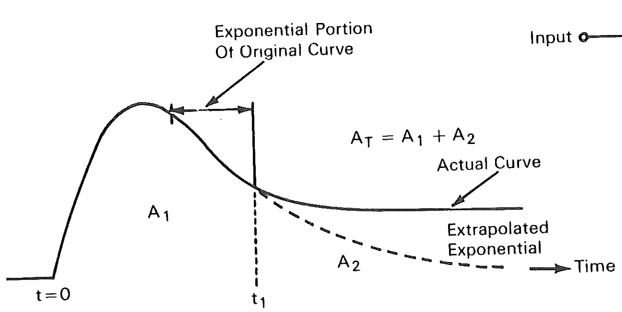
Source: (Lewis-107A)

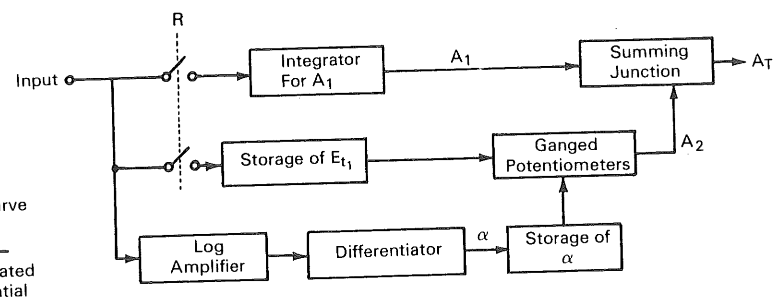
January 1966

Brief 66-10006

NASA TECH BRIEF

Computer Circuit Calculates Cardiac Output





The problem: To provide a simple automatic method of calculating cardiac output, which is defined as the blood volume per unit time and expressed in liters per minute. Typical time curves are derived and plotted from the output of a densitometer in the indicator dilution method, or a count-rate meter in the surface counting method. Previously, an extrapolated exponential curve derived from the time curve was plotted on semilog paper, and the area between the curve and baseline was calculated with a planimeter.

The solution: Electronic circuitry that automatically calculates this area under the curve and thereby eliminates the laborious manual manipulations.

How it's done: The circuitry calculates the total area A beneath the curve by summing the areas A_1 and A_2. Relay R closes at the onset of the curve and opens at t_1, which is an arbitrary point on the exponential portion of the original curve. Control of the opening of R can be by any convenient means provided that t_1 is always on the exponential portion of the original curve. When R opens, the voltage E_{t_1} (the voltage at point t_1) is automatically stored on a capacitor. Because an exponential curve becomes a straight line when plotted on log paper, the output of the log amplifier is a ramp function for the interval over which the input is an exponential time function. Also, because the derivative of a ramp function is a constant, the output voltage of the differentiator is proportional to α during the interval of the exponential. Since the maximum value of the downslope occurs during this interval, α may be stored by charging a capacitor through a diode to the maximum value of the output voltage from the differentiator.

By using cathode followers for isolation, output voltages proportional to $E_t\alpha$, and α may be obtained without discharging the capacitors. Then, using a ganged potentiometer, these voltages may be divided to produce an output voltage proportional to A_2. The summing junction adds this output to A_1 to produce a voltage proportional to the total area beneath the extrapolated curve.

Using similar techniques, the other parameters necessary for the determination of cardiac output are measured and fed into the computations and, with appropriate calibration procedures, computer output will indicate cardiac output directly in liters per minute.

(continued overleaf)

Notes:

1. This invention should prove to be a valuable tool for basic research in physiology.
2. This invention shows promise for use in doctors' offices as a diagnostic instrument.

Patent status: Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Kaman Aircraft Corporation, P.O. Box 9431, Austin 56, Texas.

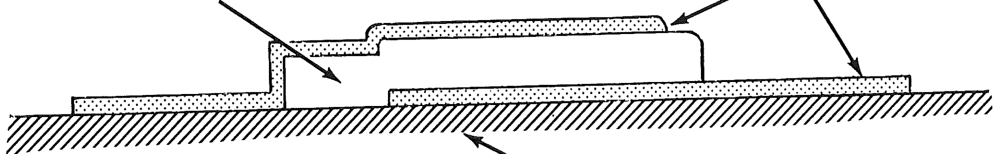
Source: Charles E. Mc Cullough of Kaman Aircraft Corporation under contract to Manned Spacecraft Center (MSC-274)

January 1966

Brief 66-10012

NASA TECH BRIEF

Thin-Film Semiconductor Rectifier Has Improved Properties



The problem:

To develop an improved thin-film semiconductor rectifier.

The solution:

A cadmium selenide (CdSe)–zinc selenide (ZnSe) film is vapor-deposited in a controlled concentration gradient onto a glass substrate to form the required junctions between vapor-deposited gold electrodes.

How it's done:

The relative proportions of CdSe and ZnSe along the thickness of the semiconductor film are varied by controlling the vapor-deposition process. In this manner, the CdSe concentration will be greater at one boundary than at the other boundary of the semiconductor film where junctions are formed with the vapor-deposited gold emitter and collector electrodes. The junction between the CdSe-rich portion of the semiconductor film and one gold electrode will present a relatively low energy barrier, whereas the junction between the ZnSe-rich portion of the semiconductor film and the other gold electrode will present a relatively large energy barrier.

The magnitude of the larger energy barrier, which primarily determines the current that can be passed through the rectifier, can be varied by an applied potential to produce an asymmetrical current-voltage characteristic. The relationship between the log of the current and the square root of the voltage is linear up to a voltage determined by the ZnSe-rich boundary.

Notes:

1. Tests on rectifier samples (0.058 cm^2 in area) made by this procedure yielded the following results:

Static rectification ratio at 0.4 volt	10^5
Forward resistance	100 ohms
Reverse breakdown potential	7 volts
Forward breakdown potential	0.3 volt
Leakage current at 4 volts reverse bias	less than 1 microamp
Maximum forward current density	2 amp/cm^2
Shelf life (room temperature)	2000 hours

2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B66-10012

(continued overleaf)

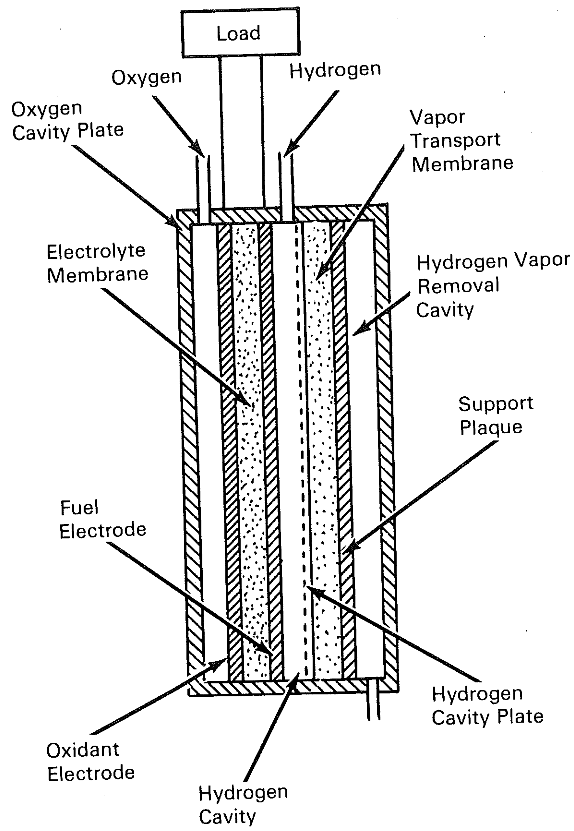
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Melpar, Inc., under contract to
Manned Spacecraft Center
(MSC-207)

NASA TECH BRIEF

Reaction Heat Used in Static Water Removal From Fuel Cells



The problem: In hydrogen–oxygen fuel cells, more water is formed at the hydrogen fuel electrode than is needed for cell reactions. If not removed as rapidly as formed, this excess water causes electrode flooding, a decrease in cell output, and ultimate cell failure. In the past, many arrangements of pumps and condensers have been used to remove this water with varying results. Such equipment requires sufficient power to seriously penalize the high efficiency of the fuel cell.

The solution: A system that uses a portion of the heat inherent in the fuel cell current generation reaction to transform excess water into water vapor and cause it to be exhausted from the cell by means of a porous vapor transport membrane adjoining a vapor removal cavity maintained at low pressure.

How it's done: As an electrical load is applied to the fuel cell, oxygen enters the oxygen cavity and

(continued overleaf)

hydrogen enters the hydrogen cavity and come in contact with the electrolyte in the electrolyte membrane through the oxidant and fuel electrodes, respectively. The gases have relatively free access to the electrolyte membrane for production of the required chemical reaction. The oxygen at the oxidant electrode reacts with the electrolyte (an aqueous solution of potassium hydroxide) and is electrochemically reduced to hydroxyl ions. The hydrogen reacts with the hydroxyl ions and is electrochemically oxidized to water, releasing electrons to the load circuit. For every unit of hydrogen oxidized, two units of water are formed at the fuel electrode. One unit of this water migrates into the electrolyte membrane to replenish the water used in the oxygen reduction. The other unit of water is waste product and must be removed from the cell.

In both of these reactions, heat is produced. Some of this heat is absorbed by the product water formed at the fuel electrode and transforms the water to a vapor. This vapor diffuses into and through the vapor transport membrane where heat of the cell causes evaporation of the water from the vapor transport membrane into the vapor removal cavity. The vapor removal cavity, through the water exhaust line, is maintained at a suitable low pressure so that the water is removed from the cell structure at a rate consistent with its generation at the fuel electrode.

Notes:

1. The requirement for fins or other cooling media on the cell is minimized by use of some of the generated heat in removal of the waste water.
2. This invention provides a compact fuel cell having high energy-to-weight and energy-to-volume ratios and requiring a minimum of auxiliary equipment.

Patent status: Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to the Allis-Chalmers Manufacturing Company, Box 512, Milwaukee, Wisconsin, 53201.

Source: John L. Platner of
Allis-Chalmers Manufacturing Company
under contract to
Marshall Space Flight Center
(M-FS-532)

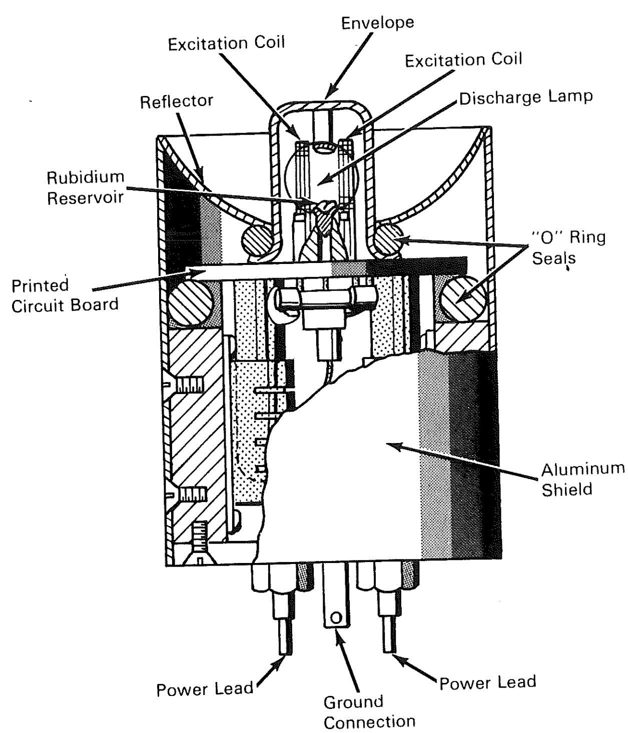
January 1966

Brief 66-10015

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Electrodeless Discharge Lamp Is Easily Started, Has High Stability



The problem: Electrodeless discharge lamps have recently come into use in various high-resolution optical systems. Two disadvantages encountered have been difficulty in starting (excitation) of the lamps and self-reversal of spectral lines at the higher frequencies due to discharge transfer between the filling gas and the alkali vapor.

The solution: An electrodeless discharge borosilicate glass lamp, partially charged with the noble gas, krypton, and containing a small amount of rubidium, enclosed in a hermetically sealed envelope that maintains the lamp at an optimum temperature during discharge. The lamp is quickly started by its excitation coil, whose inside-out configuration establishes a very strong electric field.

How it's done: The lamp is mounted between the two halves of its excitation coil inside a hermetically sealed glass envelope or dome that assures optimum discharge temperature. These components penetrate the center of a parabolic reflector.

(continued overleaf)

The alkali metal used for the vapor discharge is 1 mg of rubidium in a filling gas of krypton at 2 mm Hg. These components are mounted, with appropriate spacers, O-ring seals, and cement, to a copper-clad, glass epoxy printed circuit board, whose underside mounts a self-regulated, constant current oscillator circuit that drives the excitation coil. The entire lamp-oscillator assembly is held in a snugly fitting aluminum sleeve and is tightly cushioned against the reflector, enclosing the upper end of the sleeve, by an O-ring.

In operation, the temperature of the reservoir containing the alkali metal rubidium is maintained lower than that of the discharge region so that no condensation of vapor on the lamp walls or discharge-disturbing migration of metal particles take place.

Notes

1. This lamp has been successfully used for optical pumping in magnetometers, atomic clocks, and frequency standards.
2. This lamp is an efficient and stable source of high-resolution spectral line radiation with a very high signal-to-noise ratio.

Patent status: Title to this invention (covered by U.S. Patent No. 3,109,960), has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Varian Associates, Palo Alto 18, California.

Source: William E. Bell and Arnold L. Bloom of Varian Associates under contract to Western Operations Office (WOO-030)

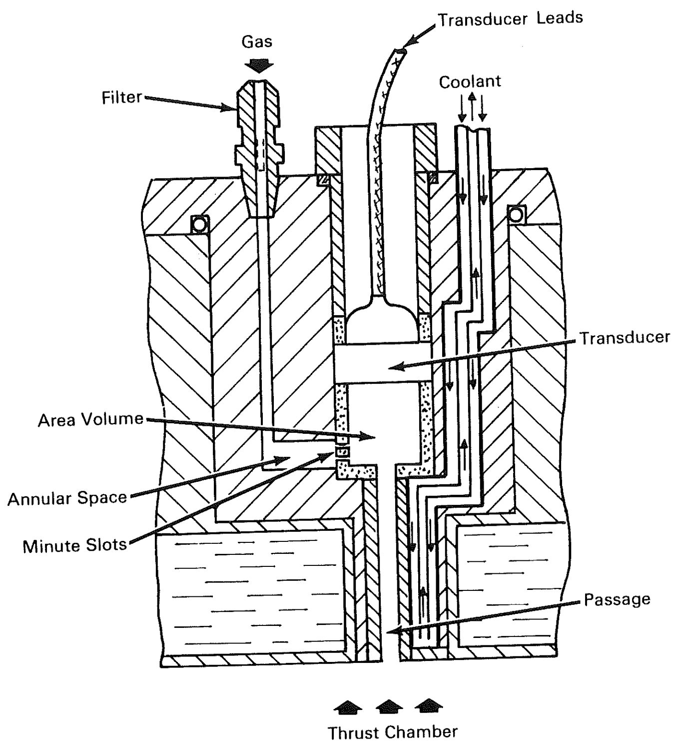
January 1966

Brief 66-10021

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Special Mount Improves Remote Transducer Accuracy



The problem:

To measure transient pressures in a hostile environment, such as the thrust chamber of a rocket motor. It is necessary in such cases to locate a transducer away from this environment. A number of complicating factors are thus introduced, such as: length, diameter, and configuration of the passage leading to the transducer, in addition to the composition and temperature of the fluid in the passage. Heat transfer to the transducer and its connecting passage and clogging by combustion products are common problems in such systems.

The solution:

A transducer-mounting device that provides free passage areas and a controlled environment for the measuring instrument.

How it's done:

The transducer is mounted in a body with a sleeve designed to provide a precise volume between the

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transducer diaphragm and a small diameter passage leading to the chamber where the pressure transients occur. A control gas is fed through a filter into an annular space that leads through four minute slots to the volume and small passage. This control gas provides a known acoustic medium between transducer diaphragm and thrust chamber and prevents clogging of the small passage by combustion products.

Thermal equilibrium is maintained in the transducer and small passage by a conditioning fluid that is circulated through an external pipe adjacent to the body of the transducer and small passage. The conditioning fluid exits by an internal pipe to compensate for heat passing through the chamber wall, or to obtain the chilling effect of a cryogenic regenerative coolant.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to Princeton University, P.O. Box 172, Princeton, New Jersey.

Source: James Preston Layton of
Princeton University under contract
to Lewis Research Center
(Lewis-269)

January 1966

Brief 66-10025

NASA TECH BRIEF

Cuprous Selenide and Sulfide Form Improved Photovoltaic Barriers

The problem:

To form chemically and electrically stable photovoltaic barriers on N-type gallium arsenide. Cuprous iodide, which has been used to form photovoltaic barriers, increases in electrical resistance when heated.

The solution:

The photovoltaic barriers are formed by depositing a layer of polycrystalline cuprous sulfide or cuprous selenide on the gallium arsenide. The chemical and electrical stability of these barrier materials is considerably greater than that of cuprous iodide.

How it's done:

The cuprous sulfide and cuprous selenide layers may be deposited on the gallium arsenide by one of the following methods: (1) electroplating elementary copper, followed by its conversion to the sulfide or selenide; (2) vacuum deposition of the copper, followed by its conversion to the sulfide or selenide; or (3) vacuum deposition of the sulfide or selenide (followed in the case of cuprous sulfide by a chemical treatment).

Notes:

1. In solar cell applications, cuprous selenide is superior to cuprous sulfide because it permits a better compromise between optical transmission and electrical sheet resistance.
2. A solar cell with a 3.7% conversion efficiency was fabricated by depositing a cuprous selenide film on a polycrystalline gallium arsenide film. The cuprous selenide barrier, without an antireflection coating, had a 75% transmission at 1 to 5 electron volts.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California, 90406
   Reference: B66-10025

Patent status:

No patent action is contemplated by NASA.

Source: Radio Corporation of America under contract to Western Operations Office (WOO-212)

Categories 01, 03

NASA TECH BRIEF

Improved Carbon Electrode Reduces Arc Sputtering

The problem: To decrease the ejection of incandescent particles from carbon electrodes. Arc sputtering, due to the ejection of these particles, causes pitting and opaquing of optical elements.

The solution: Use carbon rod cores with a smaller proportion of rare earth compounds than in cores of standard composition.

How it's done: The composition of the new core before the addition of binder is as follows:

Material	Percent by Weight
Rare Earth Fluoride (REF)	12
Rare Earth Oxide (REO)	23
Graphite, Natural Flake	52
Strontium Fluoride	10
Sulfur	3

The binder, a coal tar pitch, is added in a weight ratio of 17 parts of binder to 100 parts of the blended chemicals.

A test comparison of the relative merits of 16-mm standard cores and new cores is given below. All tests were made at an arc current of 400 amperes. The energy distribution of the new arc remained unchanged.

	Standard Core	New Core
Weight Ratio REF:REO	1:1	1:2
Graphite: (REF + REO)	1:1	1.5:1
Arc Sputtering Rate (Mg/Min)	0.26*	0.017*
Light Output Relative Center Brightness	100	95.5
Carbon Consumption (In./Hr)	58.2	50.9
Arc Power (KW)	31.2	29.6

*Ejected incandescent particles consist mainly of rare earth compounds.

Notes:
1. Production of the new cores does not involve any additional equipment or cost.
2. These cores should be valuable in high-power searchlights, theater projectors, and in equipment used for accelerated ultraviolet exposure tests in the paper, paint, textiles, and plastics industries.
3. Related innovations are described in NASA Tech Briefs B65-10018, January 1965; B65-10095, April 1965; and B65-10108, April 1965. Inquiries may also be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1547
   Houston, Texas, 77001
   Reference: B66-10026

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Union Carbide Corporation
under contract to
Manned Spacecraft Center
(MSC-219)

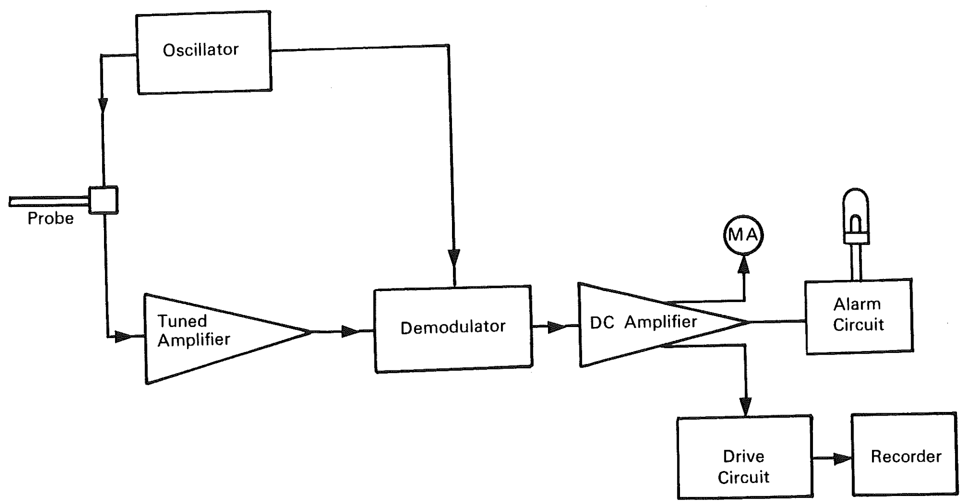
Category 01

January 1966

Brief 66-10028

NASA TECH BRIEF

Portable Self-Powered Device Detects Internal Flaws in Tubular Structures



The problem: Detecting internal mechanical flaws or the presence of hard spot impurities in electrically conductive tubing or complex tubular structures.

The solution: A portable probe and associated eddy-current-sensitive circuitry that can detect internal flaws in an electrically conductive tubular channel by recording the change in conductivity at the point of defect.

How it's done: The probe is inserted into the tubular channel. A differential transformer in the tip of the probe sets up a magnetic field in response to a signal from the oscillator. A portion of the field path is through the conductive wall of the tubular channel. If there are no flaws, the magnetic fields will be equal and opposite and will have equal and opposite linkage with the differential transformer coil. If a flaw is present, an imbalance in the flux linkage will induce a current in the coil. This current is routed through the tuned amplifier, demodulator, and dc amplifier to drive a milliammeter and an indicator lamp, and to provide an external recorded signal.

Notes:

1. In its present form the probe can analyze tubing 90 mils in diameter and 4 feet long. With development, the diameter could be reduced to 40 mils; there do not appear to be any reasonable limits to length. Since the probe is insensitive to hole diameter, it can measure flaws in large tubing.

2. The frequency at which the unit operates is a function of the material being examined. This unit was employed in the testing of graphite, for which a frequency of 200 kc was particularly effective.

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3. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Reference: B66-10028

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

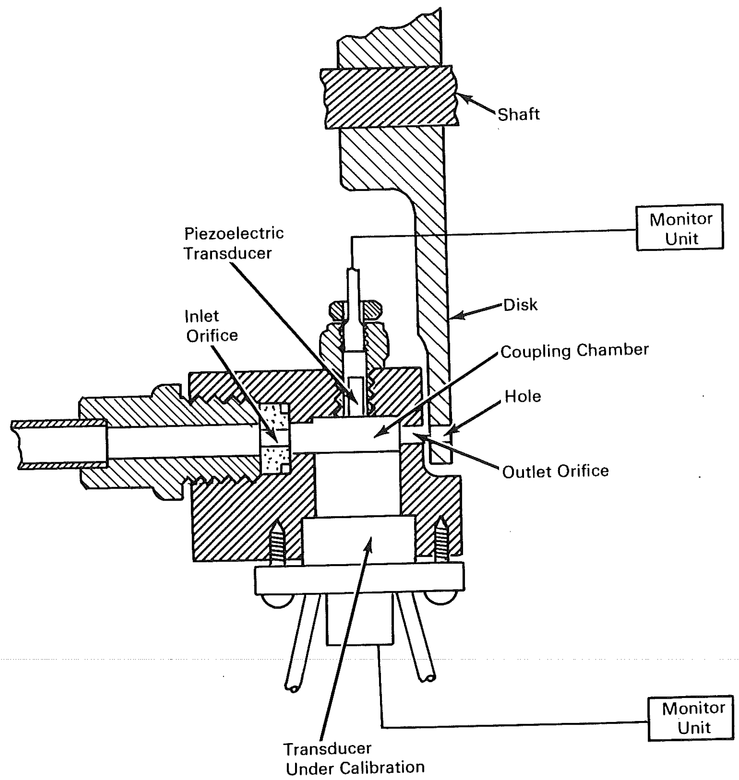
Source: G. Gilmour of
Westinghouse Astronuclear Laboratory
under contract to
Space Nuclear Propulsion Office
(NU-0019)

January 1966

Brief 66-10031

NASA TECH BRIEF

Pressure Transducers Dynamically Tested with Sinusoidal Pressure Generator



The problem:

In order to dynamically test and calibrate pressure transducers, there is a requirement for resonance free pressure signals that can be varied throughout the audiofrequency (20–20,000 cps) range. In previous devices, the driving medium modulating chamber was sufficiently resonant in the operating mode to reinforce oscillations reaching the instrument under test.

The solution:

A pressure generator assembly with a chamber having its lowest resonant mode above the audiofrequency range. Essentially true sinusoidal waveforms of useful amplitude above signal noise may then be applied to the transducer being tested.

How it's done:

The flush diaphragm transducer under test is installed so its diaphragm closes the coupling chamber.

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A second, piezoelectric type transducer is mounted in the opposite wall of the coupling chamber. The two transducer outputs are connected to electronic monitoring equipment. An exciting gas, such as helium, is forced through the inlet orifice into the coupling chamber and exits by the outlet orifice. A revolving disk, bored with a number of holes accurately spaced around its periphery and driven by a variable speed motor, alternately blocks and opens the outlet orifice causing sinusoidal pressure oscillations in the coupling chamber. The chamber is designed with a volume and configuration that places its lowest resonant frequency above the highest calibration frequency of interest.

Response of the transducer under test is obtained in the form of the ratio between the two electronic monitoring devices plotted against the pressure generator operating frequency.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to Princeton University, P.O. Box 172, Princeton, New Jersey, 08540.

Source: H. B. Jones, Jr.,
of Princeton University
under contract to
Lewis Research Center
(Lewis-268)

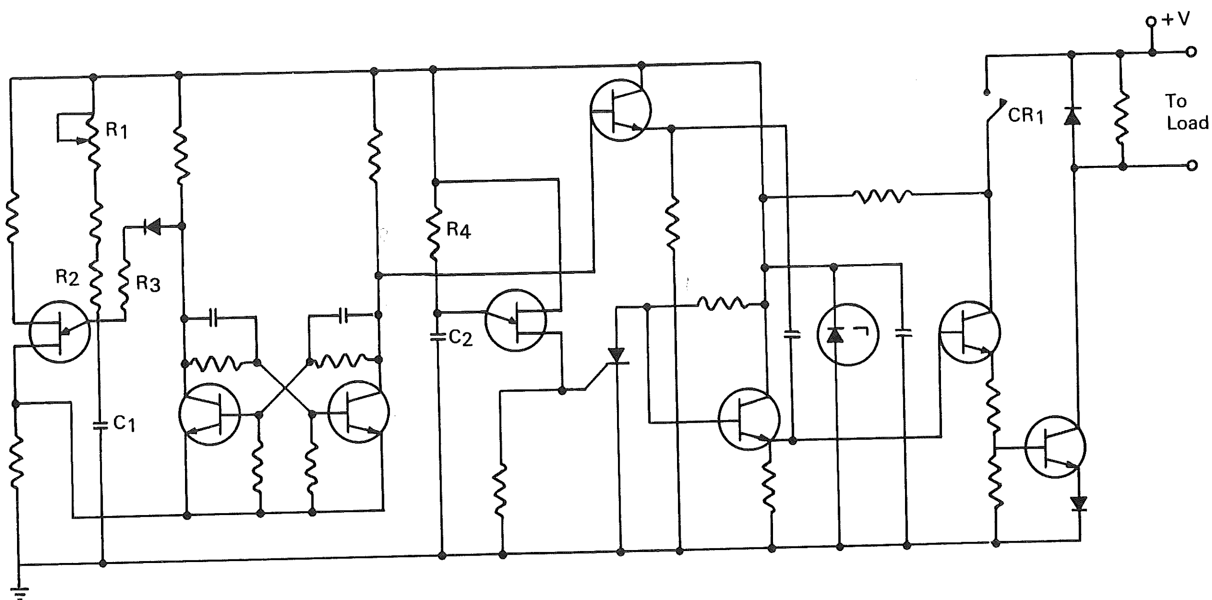
February 1966

Brief 66-10034

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Circuit Exhibits Power Efficiency Greater Than 75 Percent



The problem:

To design a circuit having high power efficiency when operating solenoid valves.

The solution:

Use a variable duty cycle pulser, to provide a low-level holding current once a high-level current has actuated the solenoid valves.

How it's done:

Initial energizing current is provided by the "one shot" pulser that causes full power to flow to the solenoid valves for a length of time sufficient for maximum pull-in. To obtain the solenoid valve holding current, a variable duty cycle pulser turns the power switch on and off. By adjusting the pulse duration and frequency, any desired value of effective solenoid valve holding current can be set and maintained. Diode CR_1 serves a dual purpose: it suppresses the induced voltage surge when the solenoid valves are deenergized, and it circulates the decaying coil current back through the coil. This effectively increases the decay time constant, making this constant independent of other circuit parameters. Thus, the duty cycle is decreased, further increasing the efficiency of the circuit.

The variable duty cycle pulser consists of a bistable multivibrator which is symmetrically emitter triggered by a unijunction relaxation oscillator. The time constant between pulses is determined primarily by the time constant $C_1 \cdot [(R_1 + R_2)]$. The time constant of the pulse is determined primarily by the time constant $C_1 \cdot [R_3 \cdot (R_1 + R_2)]/(R_1 + R_2 + R_3)$. The output of the multivibrator is capacitively coupled, through an emitter follower, to a two-stage current amplifier. The "one shot" pulser consists of a unijunction oscillator

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which triggers a silicon-controlled rectifier, which, in turn, operates a transistor switch. This switch saturates the two-stage current amplifier until the silicon-controlled rectifier conducts. The switch on the initial pulse is determined by the time constant ($C_2 \cdot R_4$). The power switch consists of the two-stage current amplifier. The voltage regulator is a simple shunt zener diode with the zener output filtered by a capacitor.

Notes:

1. The circuit illustrated has successfully operated two 8.7 ohm, 0.18 henry solenoid valves simultaneously, while the valves were under an equivalent pneumatic pressure of 220 psia. The circuit demonstrated an efficiency of 77 percent.
2. For the circuit illustrated, a minimum holding current of 0.3 amp was necessary to keep the solenoid valves held in. The pulse duration was set to 0.53 ms, and time between pulses was set to 2.6 ms, which yielded a holding current of 0.5 amp.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B66-10034

Patent status:

No patent action is contemplated by NASA.

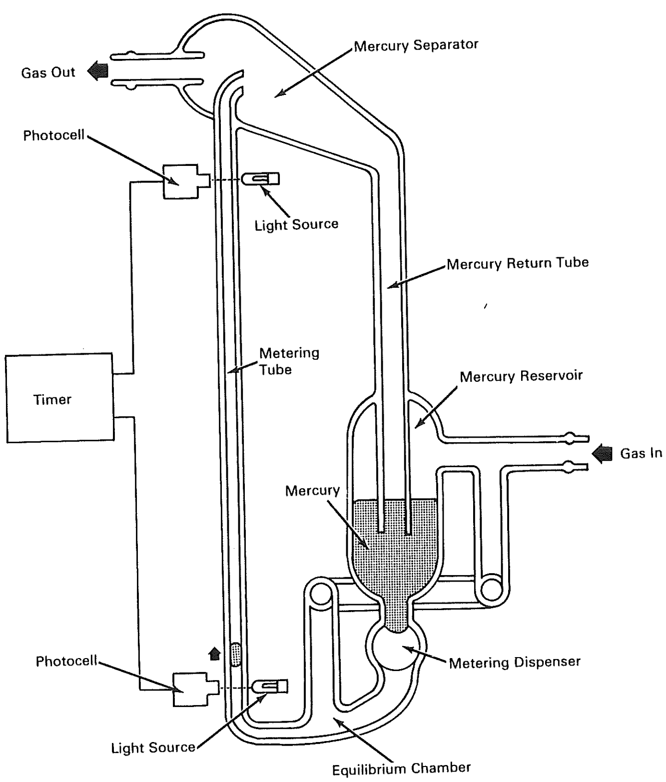
Source: Roy J. Mankovitz of
North American Aviation, Inc.,
under contract to
Manned Spacecraft Center
(MSC-254)

February 1966

Brief 66-10036

NASA TECH BRIEF

Flowmeter Measures Low Gas-Flow Rates



The problem:

To design a meter that will measure low gas-flow rates (0.015 to 0.5 cu in./min at standard pressure and temperature).

The solution:

A positive-displacement flowmeter that measures the time required for a slug of mercury to pass between two reference levels in a tube of known volume.

How it's done:

The gas admitted to the inlet tube flows in a continuous path through the equilibrium chamber, the metering tube, and the outlet connection.

In making a measurement, the mercury metering dispenser is opened to introduce a precise amount of mercury into the equilibrium chamber. The slug of mercury (approximately twice as long as the inside diameter of the metering tube) will be pushed along

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by the gas flow through the metering tube until it reaches the mercury separator, at which point it returns to the mercury reservoir for reuse. The gas flow leaves the meter through the outlet tube.

The gas flow rate is calculated by dividing the known volume of the metering tube between the lower and upper photocell reference levels by the time required for the slug of mercury to pass between the two light beams intercepted by the photocells.

Notes:

1. This laboratory flowmeter can be used for direct measurement of low gas-flow rates and as a secondary standard for calibrating other types of flowmeters.
2. A related invention is described in NASA Tech Brief 65-10137, May 1965. Inquiries may also be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10036

Patent status

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Frederick E. Wells
(M-FS-215)

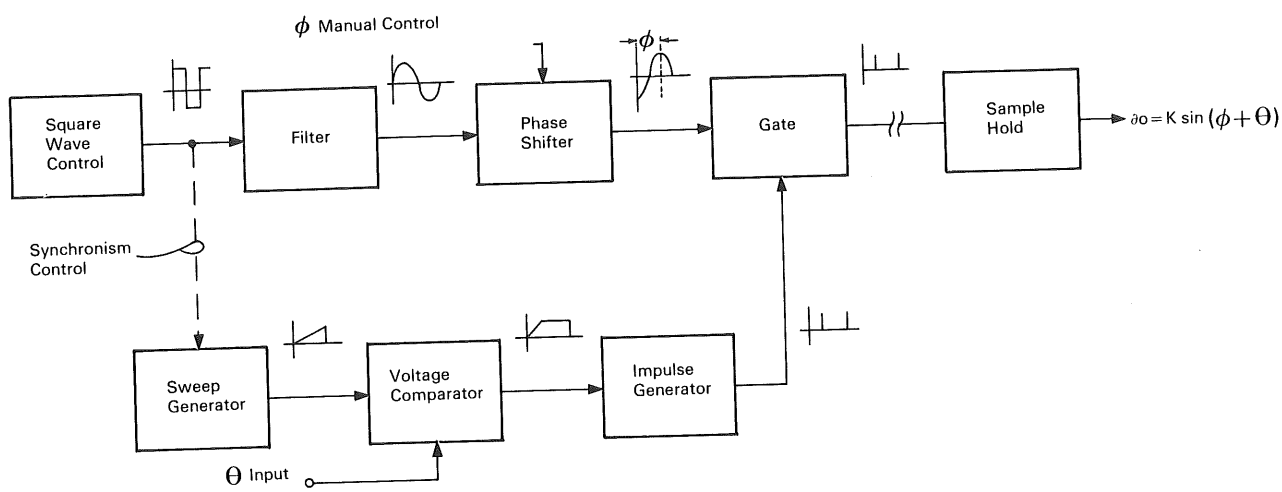
February 1966

Brief 66-10038

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Circuit Operates as Sine Function Generator



The problem: To provide an electrical signal whose magnitude is proportional to the trigonometric sine of a given angle Θ, plus or minus a fixed phase angle ϕ, when Θ is linearly proportional to the magnitude of an input electrical signal. Prior methods have used rotating electromechanical components whose dynamic accuracy is limited by the slow response time of servo controls.

The solution: A circuit that samples the magnitude of a sine wave at a point in its period determined by the magnitude of the input signal.

How it's done: The output of a square wave generator is filtered in order to recover the fundamental, which is a sine wave of the same frequency as the square wave. Simultaneously, the square wave is used to synchronize a sawtooth sweep generator. The synchronized sweep signal is one input to a voltage comparator that also receives a voltage which is linearly proportional to Θ. At a point in time when the value of Θ is equal to the magnitude of the sweep voltage, the output of the voltage comparator drives the impulse generator, which in turn opens an electronic gate for a short interval. The sine wave obtained from the filter is phase shifted through a predetermined angle ϕ by the phase shifter and this signal is passed through the gate when the impulse generator signal is applied. Thus an impulse whose magnitude is proportional to $\sin(\Theta + \phi)$ is applied to the sample hold. This sample is the output voltage, $e_o = K \sin(\Theta + \phi)$, which is maintained until the next sample is taken. The synchronism control determines the frequency of sampling, which is designed for the anticipated maximum rate of change of the input Θ, and may be as great as the fundamental frequency of the square wave. The greater the sampling rate, the more accurately the output will represent $K \sin(\Theta + \phi)$ as Θ varies with time.

(continued overleaf)

Notes:

1. The advantages of this innovation are summarized as follows:
   a. There are no moving parts, and consequently no mechanical wear, no backlash, and no dynamic lags as a result of friction and inertia.
   b. A considerable savings is realized in size, weight, and reliability over the corresponding characteristics of a mechanical system.
   c. The static accuracy is not limited by the resolution (number of turns) of a nonlinear potentiometer.
   d. The accuracy does not depend on the length of the interval over which it is desired to generate the function.

2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B66-10038

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

Source: Theodore Bogart, Jr. of
North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-255)

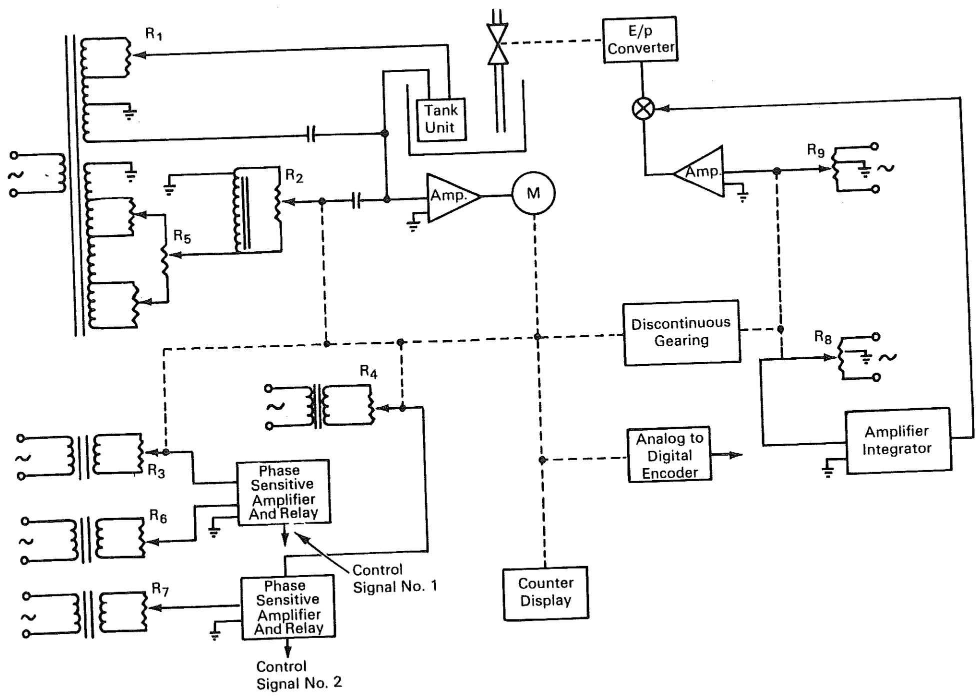
February 1966

Brief 66-10039

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Control System Maintains Selected Liquid Level



The problem: To provide a single-sensor control system, in which liquid hydrogen is controlled to fill a tank to a desired level, regardless of boiloff of the hydrogen. Conventional techniques employ separate sensors for each monitored level.

The solution: A single-sensor control system in which the output is calibrated in percentage. Thus, when the fuel is at a preselected desired level, the system output will indicate 100 percent regardless of what percent of tank capacity the fuel has reached. The output will be the control signal for desired level maintenance.

How it's done: A signal obtained from empty adjustment potentiometer R_1 is applied through the tank unit (liquid level sensor) to an amplifier–motor combination. Mechanical linkage from the motor extends to R_2, R_3, R_4, counter display, analog-to-digital encoder, and discontinuous gearing units. Potentiometer R_5 is adjusted to select the desired tank fill level, which may range from 60 to 100 percent of the tank capacity. A correction signal applied through R_2 from R_5 combines with the signal from the tank unit, and is applied as an input to the amplifier–motor combination. The motor will operate until the signal output

(continued overleaf)

from R_2 is equal (true level) to the tank unit signal; this indicates that the fuel level in the tank has reached 100 percent of the setting of R_5. The counter display unit gives a visual percentage output indicative of the wiper position of R_2. The analog-to-digital encoder, an optional circuit item, takes the analog signal provided by the gearing and provides a digital output for computer use. Potentiometers R_3 and R_4, in conjunction with R_6 and R_7, respectively, may be set to desired levels to generate control signals from phase sensitive amplifier and relay circuits.

The discontinuous gearing unit operates when the R_2 wiper is at positions representing above 95 percent of its true level. Until R_2 reaches 95 percent of its true level, the discontinuous gearing is inoperative, keeping the wipers of R_8 and R_9 at one end of the potentiometer; no control is applied through the summing circuit and the electrical-to-pressure converter (E/P converter) which allows the valve feeding liquid hydrogen to the tank unit to remain open. When R_2 reaches 95 percent of its true value, the discontinuous gearing, acting through summing circuits and the E/P converter, starts the closing of the liquid hydrogen valve. Potentiometer R_9 is the main control over the closing of the liquid hydrogen valve until R_2 has reached approximately 99.9 percent of its true value (representing 99.9 percent of a predetermined fill level in the tank unit). At 99.9 percent, vernier potentiometer R_8 becomes the controlling component until R_2 reaches 100 percent of its true value. Potentiometer R_8 can be adjusted for a slight overfill to allow for the natural boiling-off process of the liquid hydrogen.

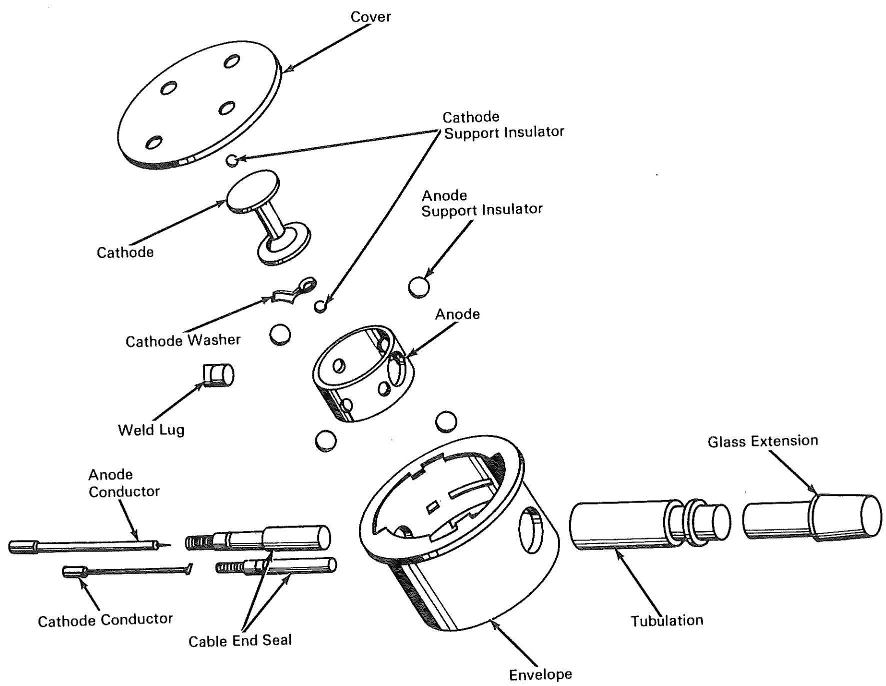
Note: This gaging system would have value in controlling liquid levels in tanks, such as in the filling of commercial tank cars where the fluids frequently boil or leak away, or for use in industrial processes where the level of fluids must be constant.

Patent status: Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Honeywell, Incorporated, 2600 Ridgway Road, Minneapolis, Minnesota, 55413.

Source: Raymond L. Bergeson and
Jack W. Schuck of
Honeywell, Incorporated
under contract to
Marshall Space Flight Center
(M-FS-470)

NASA TECH BRIEF

Cold Cathode Ionization Gauge Has Rigid Metal Housing



The problem: To design an ionization pressure gauge to accurately measure pressures to 10^{-14} torr. Hot filament gauges suffer from contamination by chemically active gases that change cathode emissive properties and hence gauge sensitivity. Cold cathode gauges of the glass envelope type suffer helium permeation of the envelope walls that reduces gauge sensitivity and requires frequent bakeout, thus losing its usefulness for long-period monitoring.

The solution: A cold cathode ionization gauge contained in a stainless-steel housing. The Penning effect is used, employing a high-voltage discharge in the presence of a magnetic field to produce an ion current proportional to gas pressure in the gauge.

How it's done: The gauge is contained in a stainless-steel housing consisting of an envelope, a cover, and a tube for attachment to the measured enclosure. Ceramic-to-metal cable end seals provide vacuumtight connections to anode and cathode. The anode is compressively held in the envelope by four support insulators that ride in the channel machined in the envelope side wall. A weld lug provides the electrical connection between anode and anode conductor. The cathode is held in place by two support insulators under compression between the bottom of the envelope and the

(continued overleaf)

cover, which has four projecting lugs on its underside to mechanically lock it to the envelope. A cathode washer press-fitted into the bottom of the cathode provides an electrical connection between cathode and cathode conductor. A glass extension of the tubulation is provided for convenience in connecting the gauge to a glass test system. A permanent cast magnet (not shown) attached pole pieces of low carbon steel surrounds the gauge tube and provides an axial magnetic field of about 1,100 oersted along the tube.

In operation, the gauge envelope is grounded, and a high voltage of the order of 3 to 6 kv is impressed on the anode. The cathode conductor is connected to a milliameter that responds to current changes on the surface of the cathode. These current changes are directly proportional to the density (particle population) of the gas being measured and, therefore, the pressure of the gas.

Notes:

1. The use of a stainless-steel, rather than glass, envelope avoids the problem of electrically charged surfaces that distort the electric field within the gauge and produce inaccurate readings.
2. This type gauge should be useful in industrial applications in the fields of metals, chemicals, food processing, cryogenics, thin-film devices, and in the operation of high-energy particle accelerators.

Patent status: Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to GCA Technology, Inc., Bedford, Massachusetts.

Source: W. S. Kreisman and R. Herzog of GCA Technology, Inc., under contract to Goddard Space Flight Center (GSFC-445)

February 1966

Brief 66-10042

NASA TECH BRIEF

Vibration Tests on Vidicons Made by Improved Method

The problem:

To devise a sensitive method for checking the performance of vidicons in mechanical vibration tests. The tests require auxiliary equipment, including a light box and test pattern, a lens system, a deflection yoke, scan generators, video amplifiers, and a display monitor. Previous methods would require that at least the light box and test pattern, lens system, and deflection yoke be mounted with the vidicon on the vibration table. Since such mounting is not practical, no high resolution testing has been done. These methods use an overlay test pattern illuminated by a point source of light. The resolution is limited to approximately 100 lines because the overlay test pattern is separated by a relatively large distance.

The solution:

Store the image of the desired fine-detail test pattern in the photosensitive surface of the vidicon, and observe the effects of the applied vibration on this image.

How it's done:

The image of the desired test pattern is stored in the photosensitive surface of the vidicon while the system is free of mechanical vibration. While the image is being stored, and until the last part of the test, the reading beam is cut off. The desired mechanical excitation is then applied and all mechanical adjustments made. Then, while the tube is being vibrated, the beam is turned on and the stored image read out and displayed. The only equipment that is required to be mounted on the vibration table and held in a fixed relationship is the deflection yoke.

Notes:

1. This method can be used in the experimental analysis of storage-type imaging tubes.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B66-10042

Patent status:

No patent action is contemplated by NASA.

Source: Hughes Aircraft Company
under contract to
Jet Propulsion Laboratory
(JPL-SC-115)

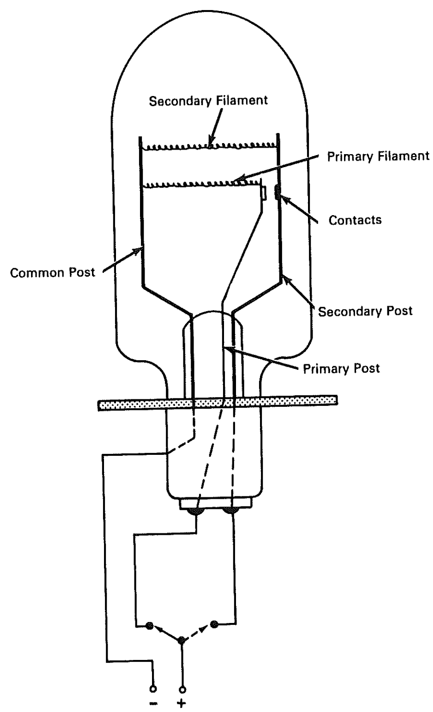
Category 01

February 1966

Brief 66-10046

NASA TECH BRIEF

Lamp Automatically Switches to New Filament on Burnout



The problem:

In many test programs, an oscillograph printout of test performance is required for analysis. Because the service life of oscillograph lamps is unpredictable, many tests are interrupted or nullified by lamp failures. The expense of such failures can be appreciable where sophisticated and complex procedures are involved.

The solution:

A lamp with a primary and a secondary filament with means for automatic switching to the secondary filament at primary filament burnout.

How it's done:

The lamp is made with two filaments supported between three posts. The primary filament connects the common post with a spring-loaded primary post. The secondary filament is mounted between the common post and fixed secondary post. An override is provided externally to permit manual switching from primary to secondary element.

With the external switch as shown, current flows through the common post, the primary filament, the spring-loaded primary post, and the switch. The primary

(continued overleaf)

filament is on and the secondary filament is off. If the primary filament burns out, the spring-loaded primary post automatically makes contact with the secondary post and current flows through the common post, the secondary filament, the secondary post to its contact, the primary post, and the switch. The primary filament is off and the secondary filament is on.

Should automatic switching fail, the override is switched to its opposite position and current flows through the common post, the secondary filament, the secondary post, and the switch. The primary filament is off and the secondary filament is on.

Notes:

1. This development is in the conceptual stage only and as of the date of this publication neither a model nor a prototype has been constructed.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10046

Patent status

No patent action is contemplated by NASA.

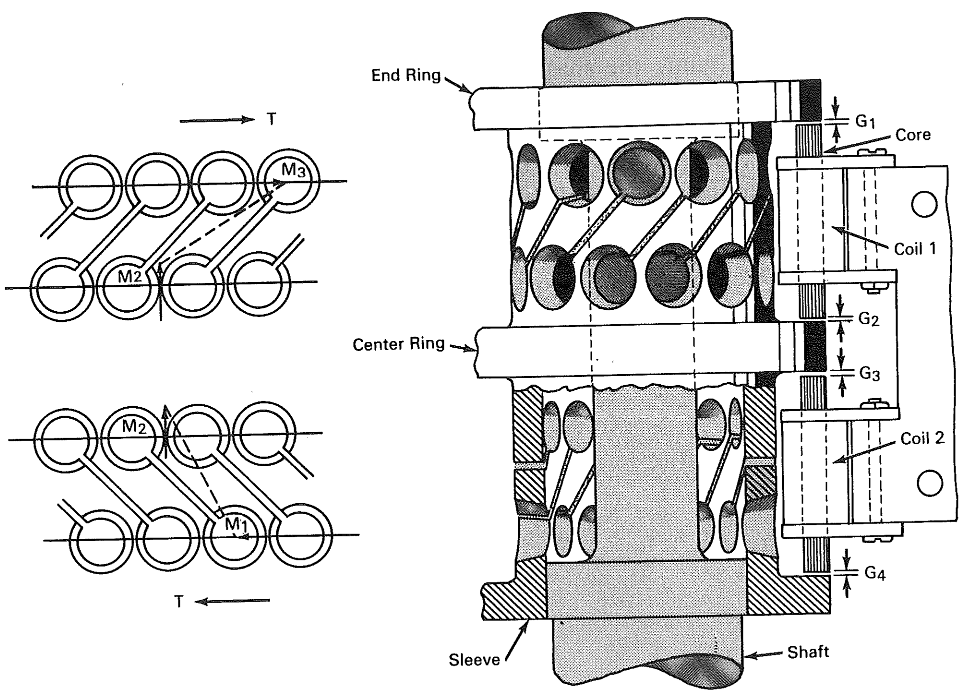
Source: Walter B. Ingle
of North American Aviation, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-498)

February 1966

Brief 66-10048

NASA TECH BRIEF

Noncontacting Transducer Measures Shaft Torque



The problem:

To design a transducer system using a noncontacting pickup to measure the output torque of a rotating shaft.

The solution:

Use a specially designed sleeve of magnetically permeable material that fits snugly over a small section of the shaft and deflects axially in direct proportion to the output torque of the rotating shaft. Stationary inductance pickup coils mounted in close proximity to, but not in contact with, the sleeve undergo a corresponding change in reluctance, which is measured by conventional circuitry connected to the pickup coils.

How it's done:

A small section of the shaft is reduced in diameter in order to ensure a relatively large torsional deflection between the two end portions of the shaft when

(continued overleaf)

torque is applied. The sleeve of magnetically permeable material is symmetrically positioned over the reduced section and secured by a shrink fit to the ends of the full-diameter shaft adjacent to the reduced section. The sleeve incorporates three integral rings, one at each end and one at the midsection. Two circumferential bands of equidistant holes are radially drilled through each portion of the sleeve between the central ring and the end rings. The holes in each pair of bands are connected by slots cut at an angle of 45° with respect to the shaft axis. The slots in one portion of the reduced section are at 90° to the slots in the other portion. The sleeve constructed in this manner has a much smaller torsional stiffness than the shaft.

When torque is applied to the shaft as indicated by T-T, the end rings will deflect in an axial direction, as indicated by M_2. Since for small deflections, $M_1 = M_2 = M_3$, axial deflection of the center ring, M_2, will be equal to $M_1 + M_3/2$ (i.e., one-half the total torsional deflection at mean sleeve radius). This axial deflection may be measured (while the shaft is rotating) by a variable reluctance circuit which incorporates four inductance coils (only one pair is illustrated) wound on laminated cores. A pair of coil assemblies is positioned between the rings to form small air gaps, G_1, G_2, G_3, and G_4. As the center ring moves axially, the gap width G_2 increases or decreases relative to G_3, thus correspondingly increasing or decreasing the reluctance of one coil relative to that of the other. Since the end rings are not deflected axially, G_1 and G_4 remain constant and do not affect the reluctance of the coils. When the two pairs of coils are connected in an ac Wheatstone bridge circuit, the output signal amplitude will be proportional to the deflection or shaft torque.

Notes:

1. This transducer system operates equally well at all shaft speeds and therefore may be calibrated statically.
2. Since no electrical or frictional contact is made with the rotating shaft, the system would be especially useful for measuring torque at high rotational speeds.
3. The effect of slight axial or radial movement of the coil assemblies is cancelled by the symmetrical design of the system.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10048

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code AGP, Washington, D.C., 20546.

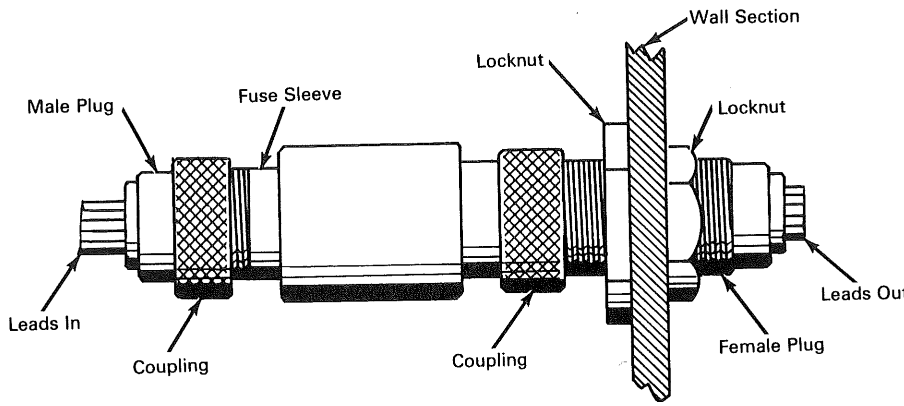
Source: North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-474)

February 1966

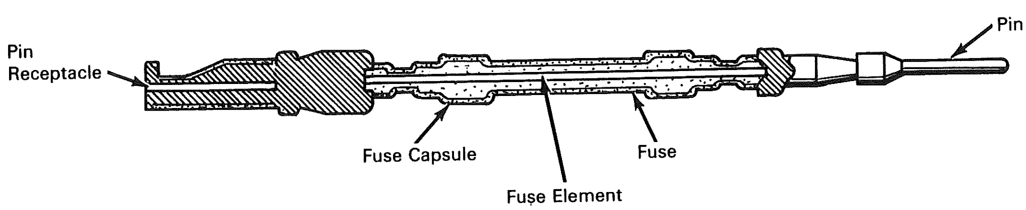
Brief 66-10050

NASA TECH BRIEF

Single Connector Provides Safety Fuses for Multiple Lines



CONNECTOR ASSEMBLY



SAFETY FUSE ASSEMBLY

The problem:

To design a single, compact device that will provide safety fuses for a number of circuits in a variety of current carrying capacities. It must protect the safety fuses and connections from the elements and be easily and quickly opened for exchange or replacement of fuses.

The solution:

A fuse-bearing sleeve for insertion between the male and female members of a multiple-line connector. The sleeve, which contains an individual safety fuse for each pin of the connector assembly, may be quickly opened for fuse replacement.

How it's done:

The connector may be mounted in a cabinet or building wall and held in place by two locknuts. A male plug has all incoming leads soldered to pins in its base. A female plug has all outgoing leads soldered to pin receptacles in its base and it includes the means of fastening to a wall section. A threaded fuse sleeve contains the required number of safety fuse assemblies (one illustrated) and includes a captive

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threaded coupling. The fuse sleeve is pressed into the female plug so all its fuse assembly pins enter the mating receptacles and is secured by tightening the coupling onto the threads of the female plug. The male plug is then pressed into the fuse sleeve so that its pins enter the pin receptacles of the various fuse assemblies and it is secured by tightening the coupling onto the threads of the fuse sleeve.

To replace or exchange fuses, the male plug is disconnected from the fuse sleeve and the fuse sleeve is removed from the wall-anchored female plug. Using a special tool (not shown), any fuse assembly may be quickly removed by pressing the tool against the shoulder of the pin and forcing the fuse assembly back out of its channel within the fuse sleeve. The replacement fuse assembly is installed by forcing it pin-first into its channel within the fuse sleeve. The fuse assembly is easily disassembled by pulling on each end of the fuse capsule and a new fuse element or one of a different value is quickly installed in the fuse.

Note:

This invention should have application wherever multiple leads carrying various current loads must be fused.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to McDonnell Aircraft Corporation, Box 516, St. Louis, Missouri, 63166.

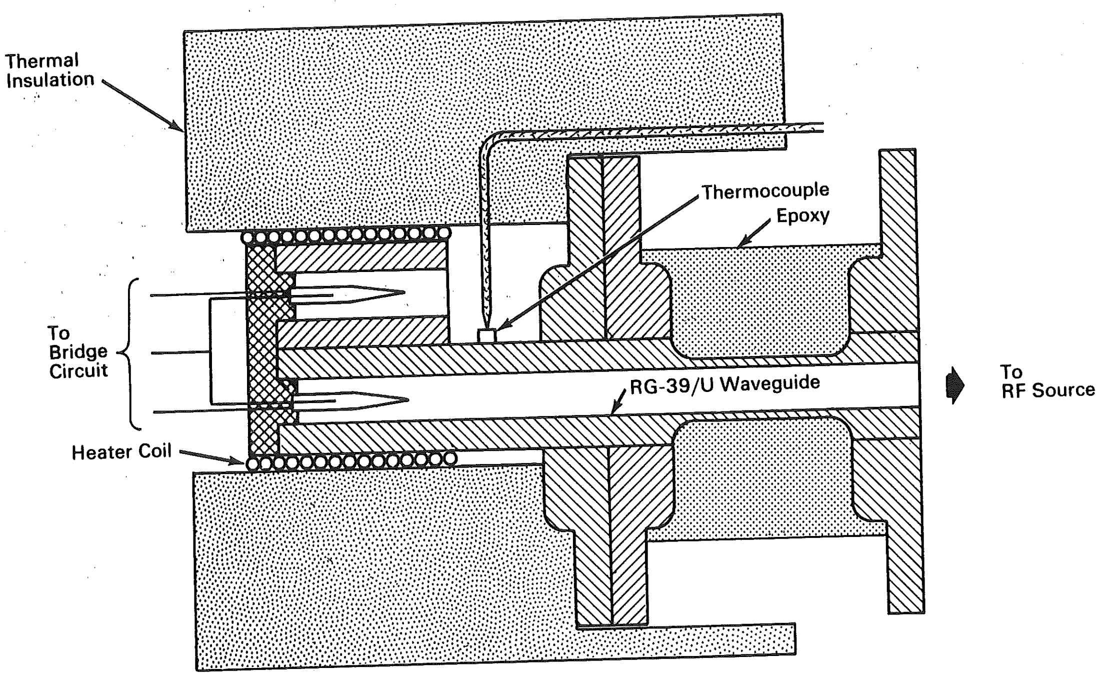
Source: George J. Weber of McDonnell Aircraft Corporation under contract to Manned Spacecraft Center (MSC-199)

February 1966

Brief 66-10051

NASA TECH BRIEF

Ferroelectric Bolometer Measures RF Absolute Power at Submillimeter Wavelengths



The problem:

Measuring low intensity rf absolute power at millimeter and submillimeter wavelengths. Such measurements are necessary to determine the operating parameters of certain electronic devices. Standard bolometer elements and calorimeters are frequency dependent and have limited sensitivity at frequencies above approximately 100 gigacycles.

The solution:

Two ferroelectric bolometer sensing elements mounted in sections of waveguide and connected in series in a standard temperature compensating bridge circuit.

How it's done:

Two precisely identical ferroelectric bolometer elements are mounted in RG-99/U waveguide sections with one of the sections connected to the rf system. The other waveguide section is in intimate contact with the first but is not illuminated with rf power. A heating coil is wound directly around the two waveguide sections and the whole assembly is wrapped with thermal insulation. A thermocouple is mounted

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in a cavity that contacts the two waveguide sections and is used to monitor the temperature in the vicinity of the ferroelectric elements. The heater coil is used to control the temperature because the dielectric constant of the ferroelectric material is most temperature sensitive at a point near its Curie temperature. The two ferroelectric elements are series connected in a temperature compensating capacitance bridge circuit that is powered by a constant 1 kc audio source. RF power absorbed by the ferroelectric bolometer produces a small temperature change which causes a large change in the permittivity and unbalances the bridge circuit. The capacitance required to rebalance the bridge is a direct measure of the absolute power applied to the ferroelectric bolometer.

Notes:

1. Power changes of less than 0.002 milliwatt have been measured at frequencies of up to 308 gigacycles.
2. Maximum sensitivity results when the ambient mount temperature is held at 94° to 96°C for a ferroelectric material consisting of a ceramic mixture of 45% lead titanate ($PbTiO_3$) and 55% strontium titanate ($SrTiO_3$) with a Curie temperature of 105°C.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10051

Patent status:

No patent action is contemplated by NASA.

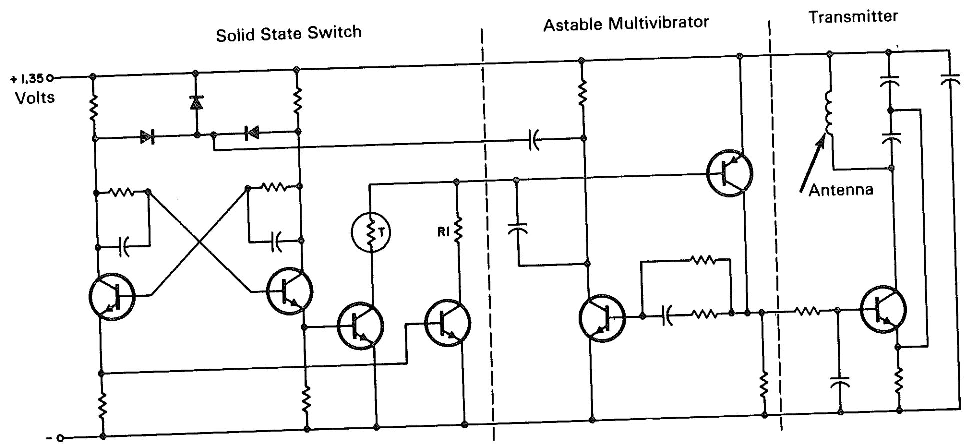
Source: Marvin Cohn and James Donald Rodgers of Advanced Technology Corporation under contract to Goddard Space Flight Center (GSFC-422)

February 1966

Brief 66-10057

NASA TECH BRIEF

Miniature Bioelectronic Device Accurately Measures and Telemeters Temperature



The problem:

To design a microminiature implantable instrument that will continuously and accurately measure and telemeter the body temperature of laboratory animals over periods up to two years. The implanted instrument must be impervious to attack by body fluids and have a negligible effect on the physical activity of the animal.

The solution:

A miniature micropower solid-state circuit employing a thermistor as a temperature sensing element (with a compensating resistor) and a FM transmitter. The circuit is designed to be very stable for a long period and to be accurate to within 0.1°C. The instrument may be constructed from conventional discrete components or integrated circuits. A special feature of the instrument with integrated circuitry is that the electronic components are sealed in a metal can, separate from the battery, so that seal rupture due to battery out-gassing is not a problem.

How it's done:

The circuit operates in the FM broadcast band and may be used with a commercial FM receiver. It transmits 15-microsecond pulses spaced 8 to 20 milliseconds apart, depending on the temperature being monitored (45° to 30°C). The average current drain of the circuit is approximately 7.4 microamperes at 1.35 volts.

A bistable multivibrator alternately switches the temperature sensor (a thermistor and a standard resistor, R1) into the frequency determining circuit of the astable multivibrator. The demodulator produces an output proportional to the ratio of the pulses obtained from the thermistor and the standard resistor.

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This ratio is used to compensate for variations in battery voltage and component values.

The integrated circuit employs a ferrite-core antenna to concentrate the rf field and prevent induction effects in the battery. The ferrite core also serves as a holder for the battery, and both components, mounted outside of the circuitry container, are sealed in wax.

Notes:

1. Although designed primarily for measuring and telemetering body temperature, the circuit can be easily modified to allow differential monitoring of other variables. The system can be extended to measurement of several variables (voltages) by replacing the bistable multivibrator with a ring counter.
2. A related invention is described in NASA Tech Brief B64-10171, October 1964. Inquiries may also be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B66-10057

Patent status:

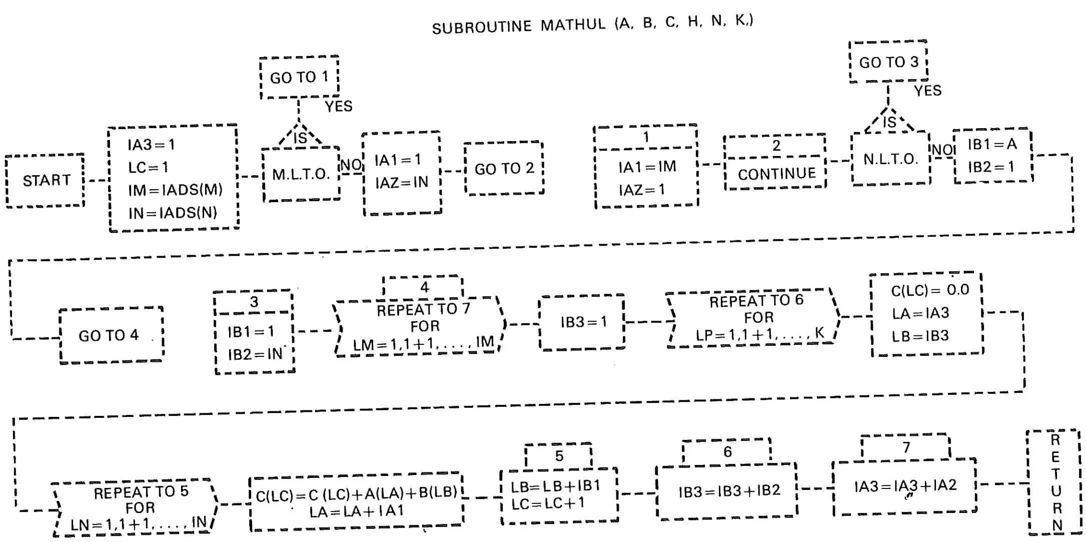
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code AGP, Washington, D.C., 20546.

Source: Thomas B. Fryer
(ARC-52)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Fortran Program Flowchart Is Automatically Produced



The problem:

Computer programs, particularly complex Fortran programs can ordinarily be understood only with the aid of a program flowchart. In addition to their time consuming preparation, hand-drawn flowcharts must be constantly updated as changes are made in the program or the original flowchart will be completely unrelated to the final program.

The solution:

A computer under control of a program called FLO-TRAN automatically produces flowcharts of Fortran program source decks fed to it. The computer output unit produces the flowcharts on either 35mm film or paper.

How it's done:

The FLO-TRAN flowcharting control program is entered into the computer in the form of a binary deck assembled from the original MAP (Macro Analysis Program) source deck. This prepares the computer for Fortran source decks and special control instructions prepared by the individual desiring the flowchart.

The interpretive section of the FLO-TRAN control program reads and interprets each of the inputs and transfers control to the executive section, which performs the necessary task. When a Fortran source deck is encountered, control is transferred to a translator that interprets and classifies the Fortran inputs. The translator then combines the information from the source cards with the control words necessary to produce the desired flowchart symbol. As the information is being processed, a binary output tape is produced that contains all the necessary source and control data to generate the flowchart on the peripheral graphic output unit.

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Notes:

1. The special control instructions of FLO-TRAN permit easy titling, listing, and insertion of special symbols.
2. When changes are made to the original source deck, FLO-TRAN will readily produce a new flowchart incorporating the changes.
3. Since the translator is an isolated part of the FLO-TRAN program, the program can be modified to produce flowcharts of source programs written in other programming languages.
4. FLO-TRAN could point out more efficient routes that sections of the source program should take.
5. FLO-TRAN could materially aid a programmer to "de-bug" a new program.
6. New users of a program can use FLO-TRAN to understand the overall "logic" of the original programmer.
7. Inquiries concerning this innovation may be directed to:

    Technology Utilization Officer
    Marshall Space Flight Center
    Huntsville, Alabama, 35812
    Reference: B66-10062

Patent status:

No patent action is contemplated by NASA.

Source: David J. Clark and Donald Williams
of General Electric Corporation
under contract to
Marshall Space Flight Center
(M-FS-369)

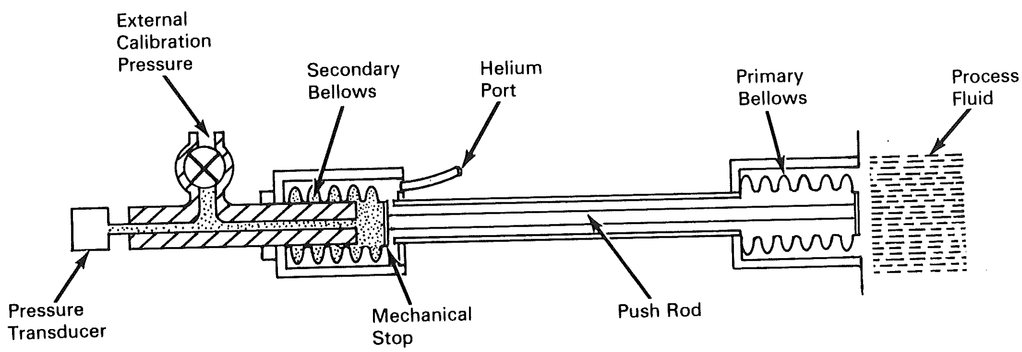
February 1966

Brief 66-10064

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Transmission System Isolates Pressure Transducer from Severe Environment



The problem:

Measuring the pressure of a high-temperature, chemically active fluid. The measuring system must provide for in-place calibration of the pressure transducer, without requiring disconnection of any of the components.

The solution:

A pressure transmission system that isolates the pressure transducer from the process fluid.

How it's done:

The transmission system consists of two bellows connected by a pushrod. Pressure on the bellows which is exposed to the process fluid is transmitted through the pushrod to the second bellows, which operates the pressure transducer. A mechanical stop is provided on the second bellows to isolate the system pressure when the transducer is calibrated in place. A valve between the second bellows and the transducer permits an external calibration pressure to be admitted for calibration.

The space between each of the bellows and the pushrod can be filled with helium to provide greater thermal isolation between the process fluid and the transducer. The helium will also allow a suitable internal pressure to be maintained to reduce the differential pressure on the bellows. The use of helium for the latter purpose would be particularly advantageous when the process fluid is at a relatively high pressure.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California, 90406
Reference: B66-10064

Patent status:

No patent action is contemplated by NASA.

Source: Space-General Corporation
under contract to
Western Operations Office
(WOO-239)

Category 01

March 1966

Brief 66-10084

NASA TECH BRIEF

Refractory Coating Protects Intricate Graphite Elements from High-Temperature Hydrogen

The problem:

To provide a refractory protective coating for graphite heater elements operating at temperatures as high as 3500°F for at least one-half hour in a hydrogen atmosphere. The intricate shape of the elements prevents application of a refractory coating by the vapor-deposition process. Uncoated graphite elements will be attacked at temperatures above approximately 2500°F.

The solution:

A composition, containing powdered tungsten, that is painted on the graphite elements and heat-treated to form a tightly adherent 3-mil-thick refractory coating.

How it's done:

The graphite heater elements are painted with a thin coat of a mixture containing the following ingredients, in parts by weight: 10 to 30 tungsten powder (325 mesh), 2 carbon black, 9 commercially available phenol-formaldehyde varnish or paint, and 0.4 maleic anhydride. The coated parts are then cured in air over the following time–temperature cycle: from room temperature to 100°C in 1 hour, at 100°C for 1/2 hour, and from 100° to 250°C in 3 hours at the rate of 50°C per hour. Following the curing cycle, the coated heater elements are baked in a 10^{-2} torr vacuum while the temperature is raised from room temperature to 850°C at the rate of 50°C per hour. The coated parts are then connected as electrical resistive loads in an atmosphere of pure methane and supplied for 2 minutes with 216 watts of power per square inch of exposed area. This treatment produces a carbonaceous crust, which is brushed off after the power is turned off. The process is completed by placing the parts in an atmosphere consisting of hydrogen and methane (5% by volume) at 200 psia and applying the electrical power at a rate increasing steadily from 226 watts to 344 watts per square inch in one hour.

Notes:

1. A coating of 3 mils thickness heated to 4000°F has withstood a hydrogen atmosphere for half an hour, with no apparent degradation.
2. This process, which is simpler and less costly than the vapor deposition process, can be used to protect graphite parts for induction furnaces. It may also have application in semiconductor technology.
3. Inquiries concerning this invention may be directed to:

   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Attn: Technology Utilization Branch
   Reference: B66-10084

Patent status:

No patent action is contemplated by NASA.

Source: C. E. Vogel, J. R. Ferris, R. L. Patterson, and R. J. Steffen
of Westinghouse Astronuclear Laboratory
under contract to
AEC-NASA Space Nuclear Propulsion Office
(NU-0027)

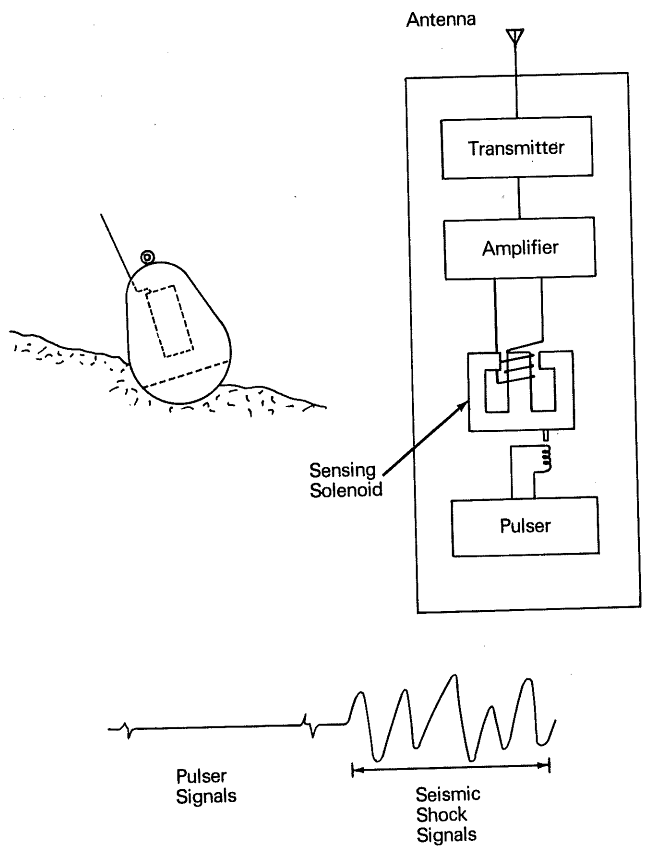
Category 01

March 1966

Brief 66-10085

NASA TECH BRIEF

Seismometer Designed for Remote Operation in Random Orientation



The problem:

To design a portable seismometer that can be placed in normally inaccessible locations, as by lowering to the ground from a helicopter or by parachute drop from an airplane, and that will operate efficiently in other than a vertically upright position. The seismometer must be packaged with appropriate telemetry equipment in order to transmit its measurements to a receiving station.

The solution:

A seismometer that is mounted in a rugged housing that contains an amplifier, transmitter, and antenna to relay measurement data to a receiving station. The instrument incorporates automatic angular adjustment

(continued overleaf)

to minimize the effect of angular error between the seismic mass axis and local vertical.

How it's done:

The seismometer responds to local disturbances by measuring the relative movement of its housing with respect to an inertial or seismic mass, and supplying an output voltage proportional to the relative displacement. In operation, shocks to the casing, caused by slight movements of the surface the unit is resting on, cause the case to move in relation to the seismic mass. A sensing solenoid, rigidly held by the case, reacts to the change in plunger-to-coil relationship, and generates a signal. This signal is amplified and fed to a transmitter for relay to a receiving station. The seismometer also incorporates a self-monitoring system that periodically signals the device's operational readiness. This system is made up of a pulser that is timed to feed impulses at regular intervals to a solenoid whose plunger is attached to the base of the seismic mass. This causes the mass to move slightly in relation to the case and a signal is generated in the sensing solenoid. This signal is of slight amplitude and readily distinguished from any generated due to surface disturbances because of its programed repetition rate.

Notes:

1. The seismometer case, in the area of the seismic mass, may be filled with a damping fluid to withstand hard impact. Automatic means may be included to vent the damping fluid following impact.
2. Electronic components in the seismometer package are protected from impact damage by standard potting techniques.
3. This seismometer may be dropped into bores in the earth or lowered to rest on the bottom of a body of water. The only modification required in such cases would be that necessary to maintain electronic system effectiveness.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to California Institute of Technology, Pasadena, California, 91109.

Source: Francis E. Lehner, et al of
California Institute of Technology
under contract to
Jet Propulsion Laboratory
(JPL-320)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Gelatin-Coated Electrodes Allow Prolonged Bioelectronic Measurements

The problem:

To develop electrodes that can be used for long-term monitoring of bioelectronic potentials in humans. The electrodes must not interact with perspiration, cause skin irritation, or promote the growth of bacteria. In addition, the electrodes must not increase in electrical resistance after prolonged use, develop counter emf's, or produce excessive galvanic potentials.

The solution:

Silver electrodes treated with an anodizing electrolyte containing gelatin.

How it's done:

A silver electrode is anodized in a 0.1M aqueous solution of KCl containing 0.1% "A" gelatin. The "A" gelatin is an acid-treated precursor gelatin with an isoelectric point at a pH of 7 to 8. In this neutral range, the gelatin molecule has a positive charge, and the charge is reversed by the addition of potassium chloride. The negatively charged gelatin molecule is thus electrostatically attracted to the anode to give a firmly bound silver–silver chloride–gelatin matrix. The gelatin permits the diffusion of simple ionic species but not large protein molecules which might "poison" the electrode and give irreproducible results.

The advantages of the gelatin-coated electrodes are (1) a low electric potential (209 microvolts), (2) stability and reversibility, (3) resistance to bacteria, and (4) compatibility with skin, since the gelatin is derived from collagen, a natural protein.

Notes:

1. These electrodes should be of considerable value in electrocardiography, electroencephalography, and impedance pneumography.
2. The Ag–AgCl electrodes described in Tech Brief B64-10025 have been found to increase in electrical resistance, with consequent attenuation of the bioelectric potential being measured, after prolonged usage.
3. Related innovations are described in NASA Tech Briefs B64-10025, May 1964; B65-10015, January 1965; and B65-10320, October 1965. Inquiries may also be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   P.O. Box 1537
   Houston, Texas, 77001
   Reference: B66-10088

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Institute of Research and Instrumentation under contract to Manned Spacecraft Center
(MSC-153)

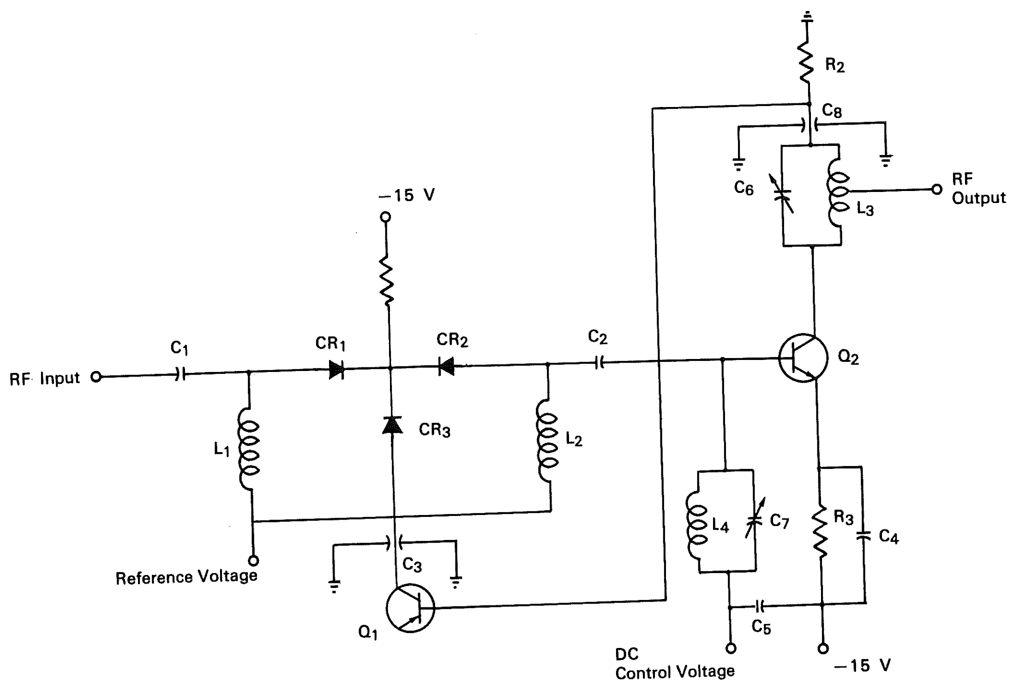
Category 01

March 1966

Brief 66-10089

NASA TECH BRIEF

Automatic Gain Control Circuit Handles Wide Input Range



The problem:

Radio receivers that must handle a wide range of input signal levels must use some form of automatic gain control (AGC) to prevent overloading the final output stage. Presently available circuits are limited to maximum undistorted input signal strength of no more than 50 millivolts rms.

The solution:

An AGC circuit capable of handling input signals of the order of 1 volt rms. The transistorized circuit maintains a relatively constant output by varying attenuation of the input signal.

How it's done:

The input signal is coupled through C_1, to the variable attenuator made up of diode tee-pad network CR_1, CR_2, and CR_3. The attenuator is prebiased in the low-attenuation condition by a reference voltage coupled through rf chokes L_1 and L_2. The attenuator control elements are R_1, C_3, and Q_1. Output of the attenuator is coupled through C_2 to reflex amplifier Q_2. The amplified rf output is taken from resonant tank circuit L_3–C_6. The dc control voltage is fed through blocking filter L_4–C_7 to the dc input of reflex amplifier Q_2. The amplified dc output voltage is developed

(continued overleaf)

across collector load resistor R_2 and is fed to attenuator control transistor Q_1. Emitter resistor R_3, in conjunction with R_2 determines the dc gain of Q_2, while C_8, C_4, and C_5 act as ac bypass condensers to maintain the rf gain of Q_2 as high as possible.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P.O. Box 1537
Houston, Texas, 77001
Reference: B66-10089

Patent status:

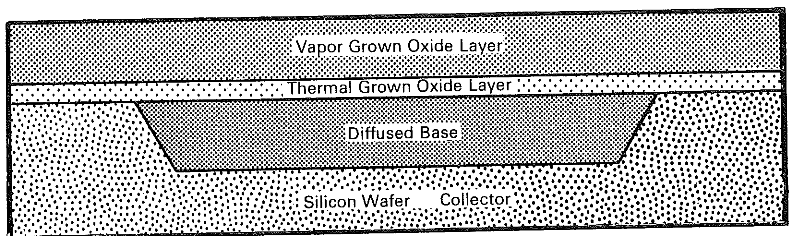
This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C., 20546.

Source: Stanley H. Black
of Sperry Gyroscope Company
under contract to
Manned Spacecraft Center
(MSC-166)

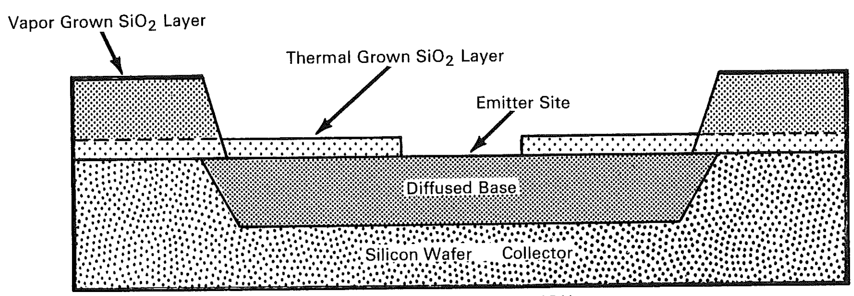
March 1966 Brief 66-10091

NASA TECH BRIEF

Vapor Grown Silicon Dioxide Improves Transistor Base-Collector Junctions



BASIC CONFIGURATION



FINAL CONFIGURATION

The problem:

To provide greater protection for the base-to-collector junction in silicon planar transistors during the emitter diffusion process. The thermally grown SiO_2 layer normally used to mask the face of the transistor is extremely thin and may have imperfections that could allow the diffusion of impurities into the silicon wafer in the critical junction region.

The solution:

A vapor grown SiO_2 layer covers the entire base-collector junction region. This provides an oxide of greater thickness than can be grown compatible with diffusion times and temperatures and fills in any imperfections that exist in the thermally grown layer.

How it's done:

A portion of the thermally grown SiO_2 layer is selectively removed from the face of the silicon wafer by photoengraving. The base region is than diffused into the silicon wafer and a second thermally grown SiO_2 layer is deposited over the entire face of the assembly. The vapor grown SiO_2 layer is now formed by a chemical reaction with silane (SiH_4) and oxygen at a temperature between 300° and 600°F. Any imperfections that may have existed in the thermally grown layer are filled by the vapor grown layer. The emitter site is next prepared by removal of appropriate portions of the vapor grown and thermally grown dioxide to expose the diffused base region. The vapor grown oxide covers imperfections that may exist in the layer of

(continued overleaf)

thermally grown oxide in the collector-base region and also prevents penetration to the silicon surface, in critical regions of the junction, of imperfections normally formed during photoengraving of emitter sites. All of the collector-base junction is adequately covered with oxide to prevent penetration of phosphorous during the subsequent emitter diffusion step.

Notes:

1. In laboratory tests, devices prepared by this process were able to deliver 50% efficiency at more than 20 watts of power and a frequency of 430 Mc. Prior devices are limited to 5 watts at such high frequency.
2. This process could be used to deposit protective SiO_2 coatings on optical surfaces.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10091

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

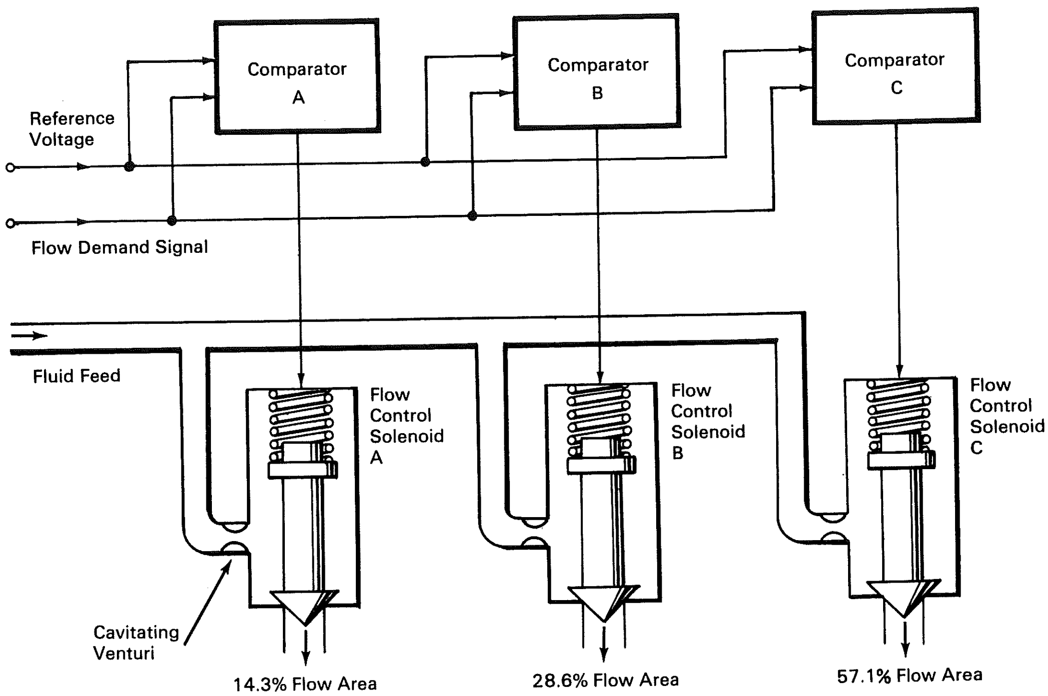
Source: Ronald A. Duclos
and Donald R. Carley
of Radio Corporation of America under contract to
Goddard Space Flight Center
(GSFC-389)

March 1966

Brief 66-10094

NASA TECH BRIEF

System Proportions Fluid-Flow in Response to Demand Signals



The problem:

To design a control system that will provide proportioned fluid-flow rates in response to demand signals.

The solution:

A system that compares a digital signal representing a flow demand, with a reference signal to yield a control voltage to one or more solenoid valves connected to orifices of predetermined size.

How it's done:

A digital flow-demand signal is compared with a reference voltage in the flip-flop comparator circuits. The voltage levels that trigger comparators A, B, and C, respectively, are in the ratio 1:2:4. The solenoid valves A, B, and C, actuated by the respective comparators are connected to separate orifices having flow areas that are also in the ratio 1:2:4. Thus, the flow rates from the fluid feed line can be

(continued overleaf)

proportioned to correspond to the area of any one of the three orifices or to any combination of these areas. The flow, expressed as a percentage of the fluid feed, from all possible combinations of the opened orifices is as follows: A, 14.3; B, 28.6; C, 57.1; A+B, 42.9; A+C, 71.4; B+C, 85.7; A+B+C, 100.0. In the general case of n branches (n solenoids and associated units) in the system, the number of attainable proportioned flow rates is 2^n-1.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the Curtiss-Wright Corporation, 304 Valley Boulevard, Wood-Ridge, New Jersey, 07075.

Source: Curtiss-Wright Corporation
under contract to
Goddard Space Flight Center
(GSFC-457)

March 1966

Brief 66-10097

NASA TECH BRIEF

Computer Program Simplifies Selection of Structural Steel Columns

The problem:

The selection of appropriate steel columns and base plates for the construction of a multistory structure is usually a tedious process. A method is required whereby the designer can rapidly select the size of steel columns which fulfill the American Institute of Steel Construction (AISC) specifications for a particular application.

The solution:

A computer program that will determine the size of steel columns and base plates required for given axial loads at points of lateral support. The program produces an easily followed printed record containing the size of section required at a particular elevation, the stress produced by the loads, and the allowable stresses for that section.

How it's done:

To use the program, a data deck containing the specifications from the AISC manual is entered into the computer, together with code data pertaining to the yield stress and the modulus of elasticity of the steel to be used, the allowable bearing stress for the concrete, elevations, and loading. The computer then prints an output table which includes the elevation of each load application, the load data, the size of column section needed for that elevation, the actual and allowable stresses on that section, and the size of base plate required.

Notes:

1. The program, available from the address below, has been written in the FORTRAN language for use on the IBM 7094 computer. It can be modified for use on other machines with little difficulty.
2. The original program was written at the time that the 1963 AISC specifications were in effect. Later specifications should have minor (if any) influence upon the program format.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Reference: B66-10097

Patent status:

No patent action is contemplated by NASA.

Source: G. S. Vissing
of the AEC-NASA Space Nuclear Propulsion Office,
Cleveland, Ohio
(NU-0044)

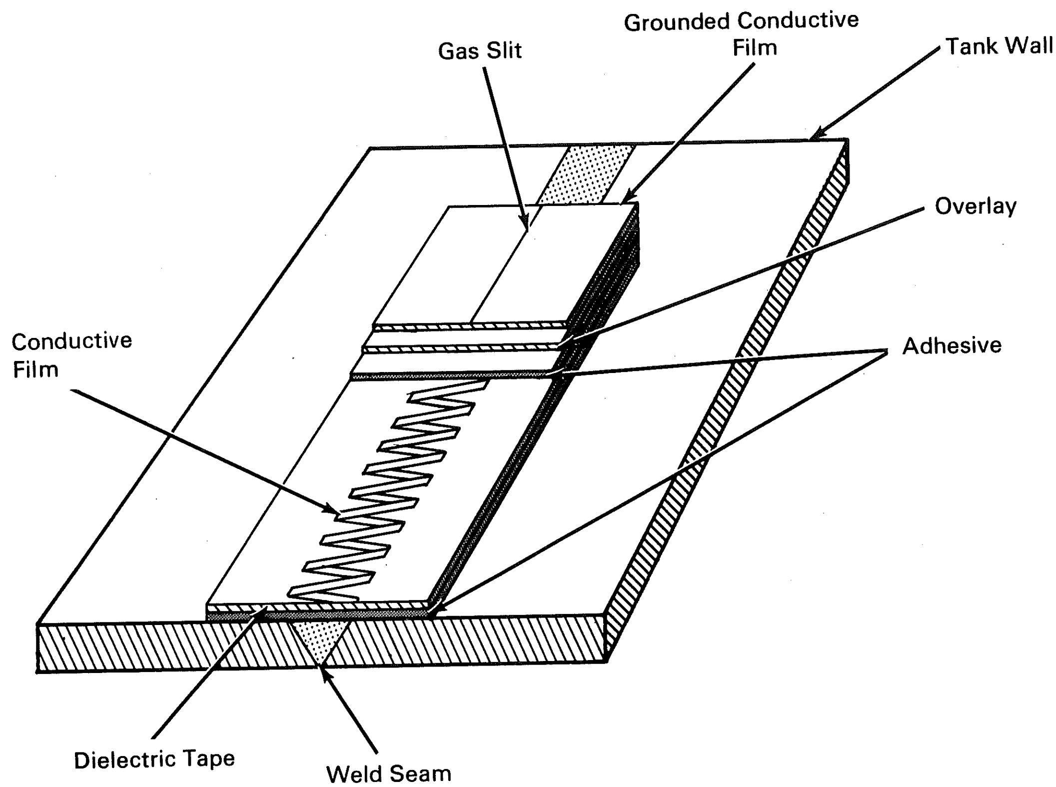
Category 01

March 1966

Brief 66-10099

NASA TECH BRIEF

Capacitive System Detects and Locates Fluid Leaks



The problem:

To design a system that will automatically detect and locate minute leaks through seams (e.g., weld joints) in large fluid-storage tanks and pipelines which may be covered with thermal insulation or are otherwise inaccessible to direct visual inspection or probing. The monitoring system must not depend on the use of tracers, which would contaminate the fluid, or electrically conductive elements, which would not be safe to apply on the walls of tanks in which gaseous or liquid fuels are stored. Neither of these systems indicate the precise location of a leak without further testing.

The solution:

An electronic monitoring system employing a capacitive tape sensing element that is adhesively bonded over seams where fluid leaks are likely to occur.

How it's done:

The tape consists of an impermeable dielectric strip on which an electrically conductive film is deposited.

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The undersurface of the tape is adhesively bonded over the weld area. The conductive film in contact with one surface of the dielectric tape, and the metal surface of the weld and adjacent portions of the tank wall in contact with the undersurface of the tape constitute the plates of a capacitor having a known capacitance per unit length. The (stretch and tear) strengths of the conductive film and dielectric tape are appreciably less than the peel resistance of the adhesive bond. The adhesive thus forms a gastight seal over the metal surface, allowing any gas that may escape from a leak to pass only into the interface between the adhesive and the underside of the dielectric tape.

When a leak develops at any point under the tape, the escaping gas will exert sufficient pressure to stretch or tear the dielectric tape, which, in turn, will cause the conductive film to rupture at that point, thereby reducing the capacitance of the system. Since the capacitance is directly proportional to the plate area (constant width x variable length) of the capacitor, a precise determination of the leak location can be readily made by measuring the capacitance change with conventional circuitry. Leads from the readout circuitry are connected to the weld and conductive film at one end of the tape sensor system.

An overlay is adhesively bonded over the conductive film to protect it from damage. A grounded conductive film may be secured (adhesively bonded, vacuum-deposited, or applied as a coating) to the overlay and electrically connected to the weld seam. This second film will provide greater detection sensitivity by increasing the effective capacitor plate area. This film will also shield the capacitor from stray electromagnetic fields.A longitudinal slit through the conductive film and the overlay can be provided to permit the escape of any trapped gas beneath the overlay.

Tests were conducted with a detection system using a composite sensing strip constructed of the following materials: 0.002″ x 0.5″ polytetrafluoroethylene, printed conductive film consisting of colloidal silver in a silicone resin base, silicone rubber base adhesives, slitted overlays consisting of 0.005″ polyethylene terephthalate, and a vacuum-deposited (grounded) conductive film. Leaks of approximately 0.01 cc per second through an aluminum plate pressurized at 5 psig were rapidly detected and located by this system.

Notes:

1. Electrically nonconducting seams can be tested for leaks by using the outermost conductive film (instead of a metal weld surface) as the second plate of the capacitor. A second capacitor plate can also be formed by interleaving a second printed conductive film between the dielectrics.
2. By connecting several points on the printed conductor to the readout circuit, the system will simultaneously detect and locate any leaks that may occur at these points along the seam.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10099

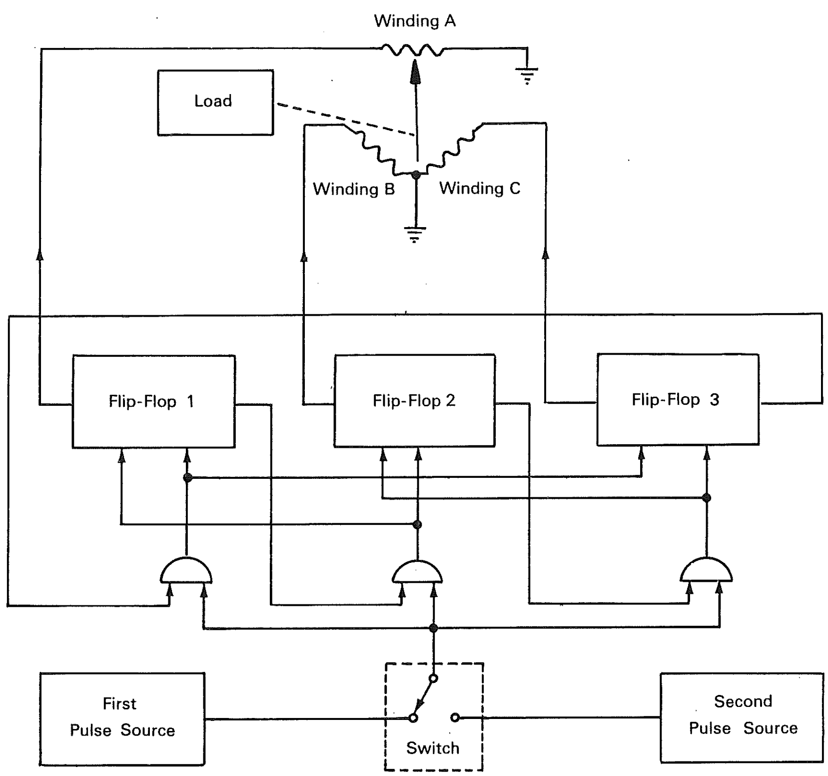
Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquires concerning license rights should be made to NASA, Code GP, Washington, D.C., 20546.

Source: North American Aviation, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-478)

NASA TECH BRIEF

Ring Counter Circuit Switches Multiphase Motor Direction of Rotation



The problem:

To reverse the direction of rotation of a multiphase motor without changing the phase wiring of the supply current source. Present relay-operated systems are bulky and present maintenance problems due to contact arcing and burning.

The solution:

A solid-state three-phase counter in which the phase sequence of the counter and hence the direction of rotation of the motor are readily reversible.

How it's done:

The three flip-flops have high current output terminals connected to the three individual phase windings of the three-phase motor, which is a stepper or indexing motor having a permanent magnet rotor that aligns itself with the field produced by the winding that is energized.

In operation, the pulse sources each supply pulses at a repetition rate of 180 per second since the motor is 60 cps, three phase. With the switch connected to

(continued overleaf)

the first pulse source, the initial pulse turns flip-flop 1 on and current is applied to winding A of the motor. The second pulse switches flip-flop 1 off and flip-flop 2 on, thus removing current from motor winding A and applying it to motor winding B. The third pulse switches flip-flop 2 off and flip-flip 3 on, removing current from motor winding B and applying it to motor winding C. The fourth pulse switches flip-flop 3 off and flip-flop 1 on and the sequence is repeated.

To reverse the motor direction of rotation, the switch is connected to the second pulse source and the above-described action is reversed with flip-flops 3, 2, and 1 being turned on and off in that order, thus powering motor windings C, B, and A in that order.

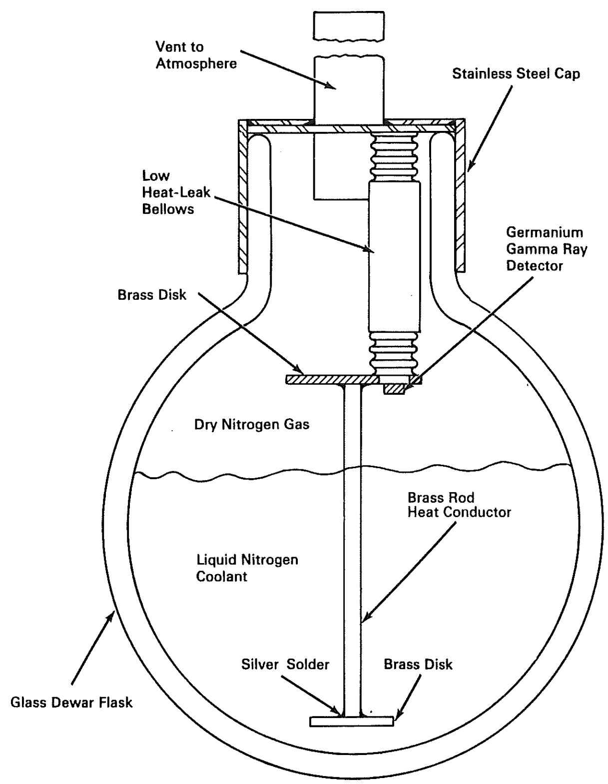
Patent status:

Title to this invention covered by U.S. Patent No. 3,112,433 has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to Space Technology Laboratories, Inc., One Space Park, Redondo Beach, California.

Source: Avard F. Fairbanks
of Space Technology Laboratories, Inc.,
under contract to
Jet Propulsion Laboratory
(JPL-SC-166)

NASA TECH BRIEF

Mount Makes Liquid Nitrogen-Cooled Gamma Ray Detector Portable



The problem:

Devise a portable liquid nitrogen-cooled gamma ray detector system. Commercially available cryostats that are used to maintain a germanium gamma-ray detector at operating temperature require attachment to a vacuum pump and frequent monitoring and replenishment of the liquid nitrogen coolant. The required external apparatus limits the portability of the detector system.

The solution:

Attach the detector to a fixture that provides a good thermal conductive path between the detector and the liquid nitrogen contained in a Dewar flask, and a low-heat-leak path between the detector and the external environment.

How it's done:

The fixture is comprised of two sections, a thermal conductive section consisting of a brass rod with a

(continued overleaf)

brass disk at each end, and an insulating section consisting of a thin-metal bellows. The upper disk of the brass rod assembly serves as a mount for the germanium gamma-ray detector and the bellows, the upper end of which is fastened to the stainless steel cap on the Dewar flask.

The dry nitrogen gas that accumulates above the liquid nitrogen surrounding the brass rod serves both as a suitable detector environment and as additional thermal insulation for the system. Since the gas is at atmospheric pressure, no external vacuum pump is required. One filling of liquid nitrogen in a two-liter Dewar flask will effectively cool the detector for approximately six days.

Notes:

1. The gamma ray source outside of the flask must be at or above the level of the coolant.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B66-10103

Patent status:

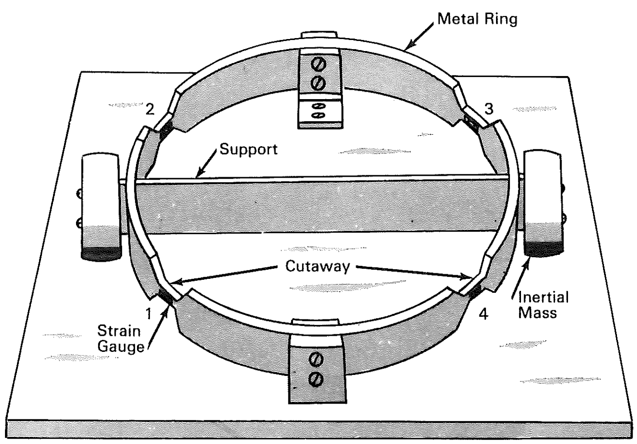
No patent action is contemplated by NASA.

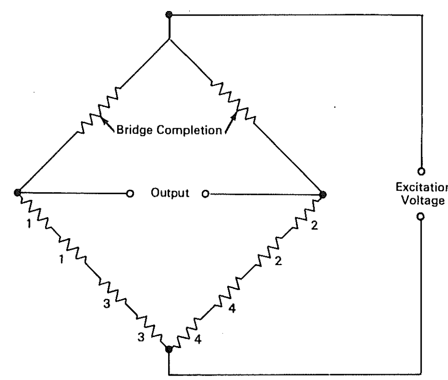
Source: Theodore E. Fessler
(Lewis-259)

March 1966 Brief 66-10105

NASA TECH BRIEF

Angular Acceleration Measured by Deflection in Sensing Ring





The problem:

To design a small, lightweight angular accelerometer of simple and inexpensive construction that will perform reliably when subjected to harsh temperature and vibration environments.

The solution:

A device that uses strain gauges to measure the amount of deflection in a metal ring caused by movement of inertial masses mounted through the ring.

How it's done:

The sensing element consists of a metal ring to which two inertial masses are mounted and joined by a common support. The ring is cut away in four places to create strain intensification areas. Strain gauges are mounted on each side of these four areas and connected to a constantly excited wheatstone bridge circuit. Inertial force of acceleration from the two inertial masses is transmitted along the sensing ring causing change in strain gauge current thus affecting bridge circuit output. The four inside strain gauges give greater overall sensitivity and provide cancellation of most effects not yielding angular acceleration data.

Notes:

1. Range of the instrument is easily varied by varying the value of the inertial masses.
2. Inquiries concerning this invention may be directed to:
   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77001
   Reference: B66-10105

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Richard Ray Richard
(MSC-250)
Category 01

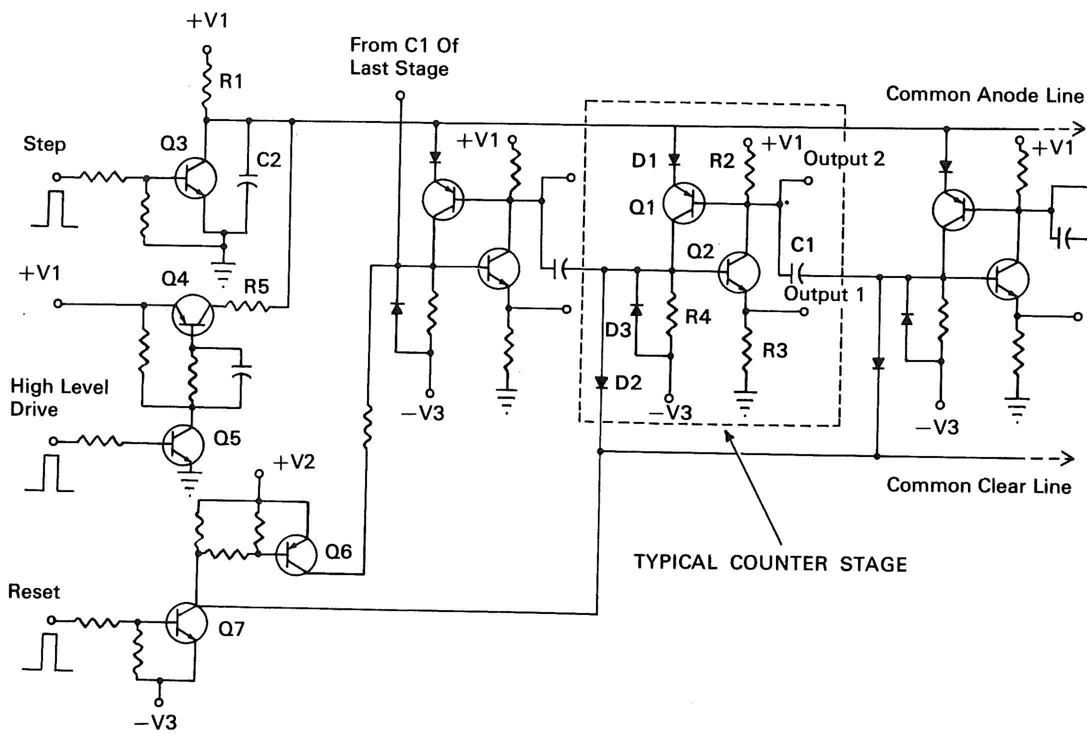
March 1966

Brief 66-10106

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Low-Power Ring Counter Drives High-Level Loads



The problem:

To design a ring counter which dissipates very low power in standby conditions, yet drives high-current loads on a low duty-factor basis.

The solution:

A counter using complementary transistors so that in one selected stage both transistors are conducting, while the transistors of the other stages are cut off. The two transistors in the selected stage carry a very low holding current, and standby dissipation is small. When high-level drive capabilities are required, the holding current is augmented by a pulse of higher current without changing the state of the counter.

How it's done:

In a typical counter stage, transistors Q1 and Q2 form a variation of a silicon-controlled switch. Once the transistors have been turned on by a pulse of current into the base of Q2, they will remain saturated as long as current is flowing through the emitter of Q1. When this holding current is removed, both transistors turn off. While the stage is on, the amplitude of this holding current may be varied over a very wide range without changing the state of the transistors.

(continued overleaf)

A ring counter is made of a number of interconnected stages. By capacitively coupling the output of one stage to the input of the next, the positive-going wavefront of a stage turning off serves to turn on the following one. Counter operation is initiated by pulsing the reset circuit, which turns on the first stage and turns off any other stage which may be on. Holding current then flows through R1 and the common anode line into the first stage. The counter is stepped by momentarily turning on Q3, thus shunting the holding current and causing the first stage to turn off and the second to turn on.

Two types of high-current load may be driven from the counter stage. The first load, connected to output 1, accepts current. The second, connected to output 2, supplies current. Drive capability for both types is provided by pulsing the high-level drive circuit to supplement the holding current to the extent required by the load. Since this high-level capability is required for very short times, the average dissipation is low. Output 1 is intended for driving directly the base of an NPN transistor whose emitter is grounded. If a high-impedance load is connected to that point, the voltage step developed across it during a high-level interval would also appear at the collector of Q2 and might, when coupled through C1, be sufficient to turn on the following stage. When output 1 is not used, R3 should be omitted, and the emitter of Q2 grounded.

Notes:

1. A ring counter requires one stage per count, in contrast to a binary counter in which n stages provide a count of 2^n. In order to cut down on the number of ring counter stages required to achieve a high count, it is possible to use two-dimensional matrix selection. In this technique, two ring counters are used, with the product of the numbers of their stages equaling the required count. The counters are arranged so that each time one counter steps through all its stages, the second counter is stepped once. Thus, by the time the second counter has stepped through all of its stages, the number of distinct combinations achieved is equal to the product of the counters' stages.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10106

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

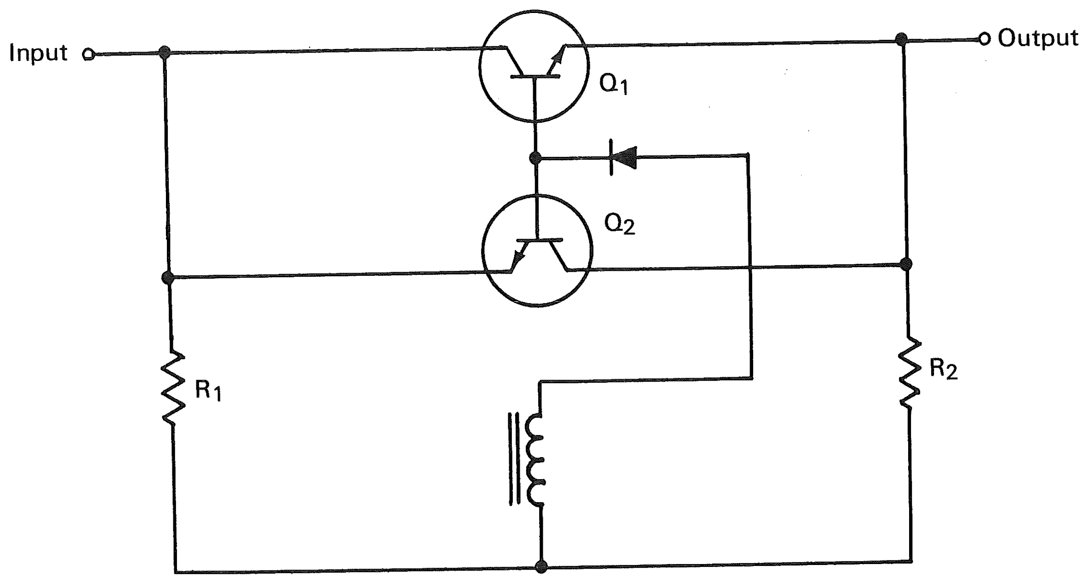
Source: UNIVAC Division of Sperry Rand
under contract to
Goddard Space Flight Center
(GSFC-431)

March 1966

Brief 66-10113

NASA TECH BRIEF

Improved Chopper Circuit Uses Parallel Transistors



The problem:

To develop a transistor chopper circuit with improved performance over that of a series transistor chopper circuit. In the series circuit the saturation resistances of the transistor pair add and become one of the major causes of chopper loss. The series circuit also requires close matching of transistors in order to accomplish cancellation of the offset voltages appearing at the outputs due to base drive current in the transistor junctions. Matched characteristics degrade during the operating life of the transistors causing degraded chopper performance.

The solution:

A parallel transistor chopper circuit in which one transistor operates in the forward mode and the other operates in the inverse mode, thus acting as a single, symmetrical, bidirectional transistor.

How it's done:

The active chopping element is composed of Q_1 and Q_2 operating in parallel. The transformer (only the secondary is shown) couples the chopper drive signal into the chopping element. The peak amplitude of the chopper drive signal is adjusted to be greater than the maximum input voltage being chopped to prevent the input signal from overriding the chopper drive signal. This prevents the transistor pair from turning on when the chopper drive signal is in the negative half of its cycle.

When the drive signal is in the negative half of its cycle, the diode will be reverse biased, blocking the

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flow of base current and turning off the transistor pair. The chopping element leakage during this portion of the cycle is determined by the sum of resistances R_1 and R_2. The use of planar construction in the transistors allows satisfactory operation in this half of the cycle, without negative base voltage, to insure cutoff.

When the drive signal is in the positive half of its cycle, the diode will be forward biased and current from the transformer will flow to the bases of Q_1 and Q_2. Current will flow through the collector-base junction of Q_1 and the emitter-base junction of Q_2 in parallel and back to the transformer through R_1. At the same time, current will also flow through the emitter-base junction of Q_1 and the collector-base junction of Q_2 in parallel back to the transformer through R_2. All four transistor junctions are thus biased on, enabling the transistor pair to conduct current from the input voltage source to the output in either direction.

The parallel circuit has a combined saturation resistance two to four times less than the series circuit. The voltage developed in one junction is partly cancelled by the voltage developed in the other junction. Only the difference of these voltages appears from collector to emitter. The transistor operating in the inverse mode (lowest saturation resistance) shunts the voltage difference developed by the transistor operating in the forward mode, thus further reducing and stabilizing the offset voltage.

Notes:

1. The sum of the emitter-base breakdown voltages for the two transistors determines the maximum input voltage that can be chopped.
2. Resistors R_1 and R_2 should be equal in value to within a few percent to insure good symmetry and low offset voltages. The value of the resistors should be selected so that the average base current from either resistor will be slightly greater than the maximum current being chopped. Increasing the base current beyond this point will give slightly lower saturation resistance at the expense of increased chopper noise.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10113

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

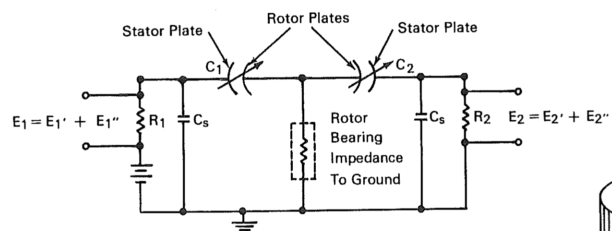
Source: International Business Machines
under contract to
Marshall Space Flight Center
(M-FS-468)

March 1966

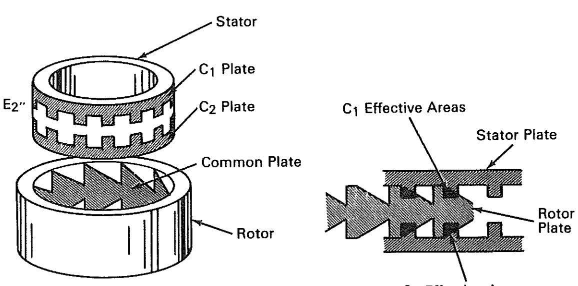
Brief 66-10126

NASA TECH BRIEF

Variable-Capacitance Tachometer Eliminates Troublesome Magnetic Fields



EQUIVALENT CIRCUIT



ELEMENTS OF DUAL VARIABLE CAPACITOR PATTERN

The problem:

To design a tachometer that does not use magnetic components for the measurement of angular speed and sense of rotation. The magnetic flux from the permanent magnet in a conventional tachometer may interfere with associated instrumentation in an electromechanical system.

The solution:

A dual variable-capacitance tachometer.

How it's done:

The variable capacitors C_1 and C_2 consist of two sets of shaped, complementary plates mounted on a stator and rotor, respectively, of accurate diametrical and concentricity relationship to provide a uniform airgap between the capacitor plates. The values of the two capacitors are equal at any instant and change at equal rates in correspondence with the rotor speed. The variable capacitor plates are shaped to provide eight output pulses per rotor revolution, and a pulse polarity dependent upon sense of rotation.

During operation of the tachometer, the time-varying voltages E_1 and E_2 developed across resistors R_1, and R_2, respectively, are fed to a differential amplifier. Each of these voltages consists of two components. Voltage components E_1' and E_2', which result from charges induced on the rotor from the ac motor drive, are of equal polarity and cancel each other at the input to the differential amplifier. The charges on C_1 and C_2 from the dc voltage source will flow through resistors R_1 and R_2 in a direction to develop voltage components E_1'' and E_2'' of opposite polarity when the capacitors change value. The difference in voltage between these components is the useful tachometer signal, which is amplified and monitored.

Notes:

1. The amplifier consists of an input differential stage, a gain stage, and an emitter follower.
2. A leakage path to ground through the rotor bearing reduces possible electrostatic charge accumulations. Fixed shunt capacitances C_s provide further protection from motor drive noise.

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3. The flux measured at an 18-inch radius from the rotor center was approximately 5 gamma, without ac motor excitation. Under the same conditions of measurement, a magnetic tachometer produced a field of approximately 250 gamma.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10126

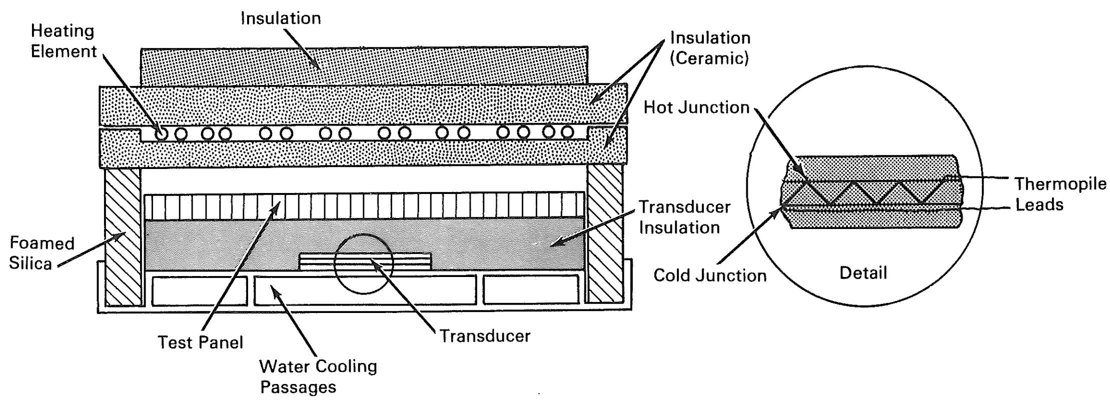
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Bendix Corporation
under contract to
Goddard Space Flight Center
(GSFC-435)

NASA TECH BRIEF

Apparatus Measures Thermal Conductivity of Honeycomb-Core Panels



The problem:

To devise an experimental method for measuring the overall thermal conductivity of honeycomb-core panels at elevated temperatures (670° to 1050°K). Since at the higher temperatures, there are three significant modes of heat transfer (conduction, convection, and radiation) through such panels, it is difficult to determine their overall thermal conductivity by analytical calculations.

The solution:

The measurements are made on panels of sufficient surface area to ensure a negligible lateral heat flow in an apparatus consisting of a heater assembly and a calibrated heat-rate transducer, with sufficient space between the heater and transducer for insertion of a test panel and insulation.

How it's done:

The heat-rate transducer is bonded to a water-cooled metal plate with a cement of high thermal conductivity. The insulation that separates the transducer from the test panel has a thermal conductivity closely matching that of the transducer. This insulation has the two-fold purpose of raising the average temperature of the test panel and preventing the transducer from overheating.

The transducer, which produces an electromotive force proportional to the heat-flow rate, is composed of a silver-constantan thermopile. This thermopile is arranged in a thin phenolic resin plate sandwiched between two other phenolic resin plates. The series of thermocouples making up the thermopile is positioned so that one set of junctions is on one face of the middle plate and the other set of junctions is on the opposite face of the middle plate. Heat flow by radiation from the ceramic plate supporting the heating elements causes a difference in temperature across the middle plate and thus generates an electromotive force.

In making a measurement, the conductivity apparatus, with the test panel in place, is sealed in a vacuum chamber which is then evacuated to a pressure of 500 microns of mercury. A controlled current is

(continued overleaf)

then applied to the heating elements to bring the top surface of the test panel up to the desired temperature and ensure a steady-state heat-flow rate through the panel, as indicated by a constant output from the heat-rate transducer. The recorded output value from the transducer is used to calculate the overall thermal conductivity of the test panel.

Notes:

1. Further information concerning the apparatus and method of measurement is given in NASA TN D-2866, "Experimental Verification of an Analytical Determination of Overall Thermal Conductivity of Honeycomb-Core Panels" by C. W. Stroud, June 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.
2. Inquiries may also be directed to:
   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia, 23365
   Reference: B66-10127

Patent status:

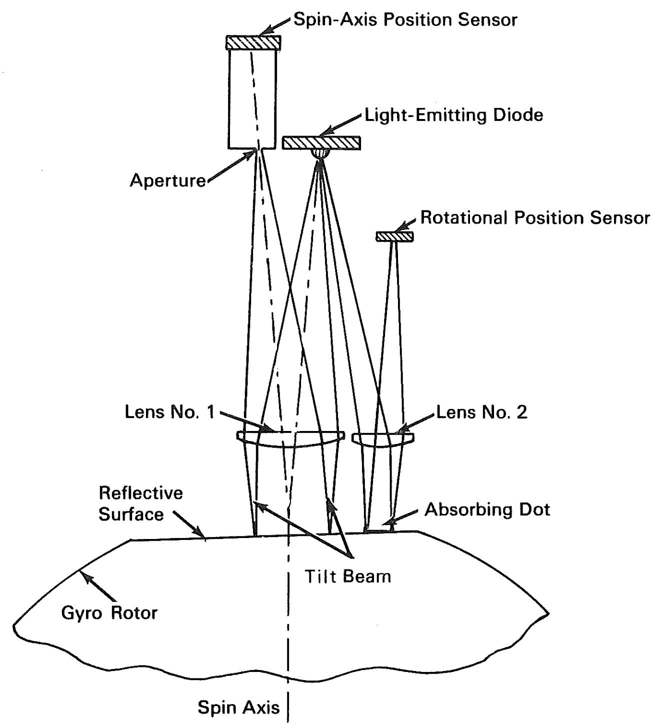
No patent action is contemplated by NASA.

Source: (Langley-202)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Optical Gyro Pickoff Operates at Cryogenic Temperatures



The problem:

To devise an efficient two-axis pickoff for cryogenic gyros. Conventional optical pickoffs, which are designed to operate at normal temperatures, require optical windows in the thermal shielding when used with a cryogenic gyro. These windows cause large heat leaks, which increase the refrigeration load on the cryogenic system. Furthermore, hot-filament or ionized-gas light sources used in conventional optical pickoffs decrease in efficiency at cryogenic temperatures.

The solution:

A two-axis pickoff using solid-state light sources and sensors which operate efficiently at cryogenic temperatures.

How it's done:

The pickoffs incorporate recently developed solid-state light sources that convert electrical energy directly to light energy (generally in the infrared range) with efficiencies ranging from 1% at room temperature (300° K) to 30% at 4° K.

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The schematic illustration shows a pickoff design that does not require a close alignment tolerance between the spin axis and the reference plane (mirror on gyro rotor). The reference plane is purposely tipped with respect to the spin axis to produce a wobble in the plane when the gyro rotor is spinning. Light from the light-emitting diode is projected through an autocollimating lens onto the wobbling mirror. The reflected image of the light source passes through the same lens and is focused on the aperture to the spin axis position sensor. As this spot of light moves around in a circle, because of rotation wobble, varying amounts of light pass through the aperture, going from a minimum to a maximum during half a rotation of the rotor and reversing during the second half. At one particular tilt position, the amount of light is constant in any rotational position, which is the pickoff zero. As the spinning axis tilts from this position, the ac signal component changes in a definite pattern.

To define a reference axis, a small light-absorbing dot is placed on the rotor flat outside the area of the tilt beam. This dot will produce an output pulse at the rotational position sensor, which will trigger a slaved oscillator. The output from this oscillator acts as a phase reference for separating tilt about the two axes perpendicular to the spin axis.

Notes:

1. The advantages of this system over other known pickoffs for cryogenic operation are: compactness of design (0.5 × 0.75 inch), high efficiency of light source, long life of solid-state light source and sensor (compared to standard incandescent source and photomultiplier), negligible drift, short response time (allowing operation at high frequencies), and good spectral match of light source and sensor.
2. Inquiries concerning this invention and other approaches to the design of a two-axis pickoff employing a solid-state light source and sensor may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10128

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546

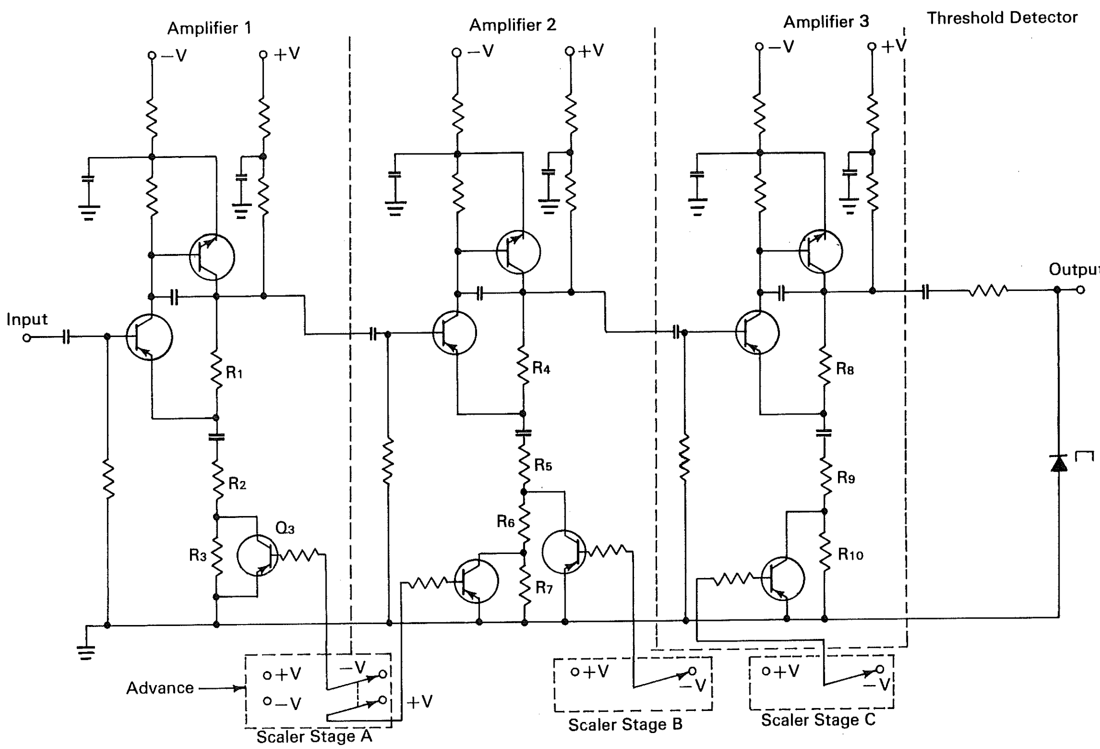
Source: General Electric Company
under contract to
Marshall Space Flight Center
(M-FS-407)

March 1966

Brief 66-10129

NASA TECH BRIEF

Digitally Controlled Pulse-Level Discriminator Operates Over Wide Voltage Range



The problem:

Designing a low power-drain discriminator circuit that will generate an output pulse when an input pulse exceeds a discrete digitally controlled threshold voltage. The discriminator must operate over a wide linear or nonlinear range of threshold levels. Conventional discriminators employ unduly complex circuitry to convert the digital settings to threshold-voltage references and compare them with the input pulses. These discriminators are limited to a narrow linear range and operate at relatively low efficiency.

The solution:

A discriminator employing several amplifier stages ahead of a fixed-reference threshold detector consisting of a tunnel diode in series with a resistor. Binary scaler stages are used to control the overall amplifier gains corresponding to discrete input signal threshold levels. The discriminator can be designed to operate

(continued overleaf)

over a wide linear or nonlinear range by direct digital control.

How it's done:

An eight-level discriminator that operates over a wide range of threshold voltages is shown in the circuit diagram. Amplifiers 1, 2, and 3 are similar transistor feedback amplifiers. Appropriate selection of the feedback resistors R_1 through R_{10} permits each amplifier to operate at one of two or three discrete gains. One of these gains can be set by the scaler stages connected to the respective amplifier. The overall gain of the three amplifiers, which is the product of the individual amplifier gains, can thus have eight discrete values corresponding to the eight possible combinations of states of the three scaler stages. The minimum input (threshold) signal required to trigger the threshold detector (and thereby yield an output pulse) can therefore be set at eight discrete levels by the scaler stages. For example, if the scalers select an overall amplifier gain of 48, a 30-millivolt (minimum) input pulse will trigger the threshold detector (1.44 volt fixed threshold); whereas for an overall gain of 24, a 60-millivolt input pulse is required for triggering.

The basis of selecting the feedback resistors can be understood with reference to the operation of amplifier 1. Transistor Q_3, shunting resistor R_3, is biased on or off depending on the state of Scaler stage A. With Q_3 biased off, the amplifier gain is $(R_1+R_2+R_3)/(R_2+R_3)$. With Q_3 biased on, the effective value of R_3 is 0, and the gain is $(R_1+R_2)/R_2$. Appropriate selection of the individual resistances yields the two discrete gains required of Amplifier 1. Similarly, appropriate selection of R_4, R_5, R_6, R_7, and of R_8, R_9, R_{10} yield the discrete gains required of Amplifiers 2 and 3, respectively.

Notes:

1. The number of threshold levels can be changed by changing the number of amplifier and scaler stages. The maximum number of levels is limited by the dynamic range and gain accuracy of the amplifiers.
2. By appropriate selection of the amplifier gains and scaler controls, the discriminator will operate over various linear and/or nonlinear (e.g., logarithmic) ranges.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10129

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Ciro A. Cancro
(GSFC-324)

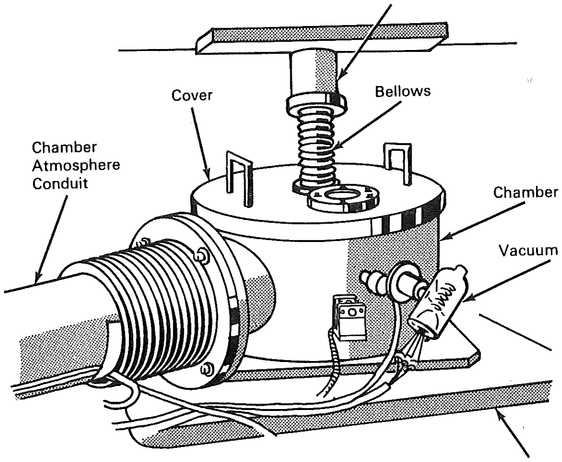
March 1966

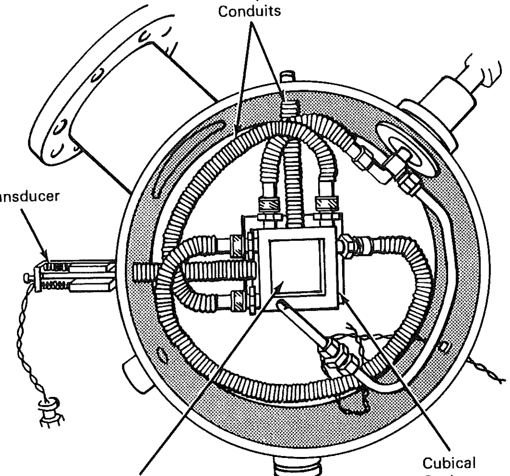
Brief 66-10130

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Materials Physically Tested in Variable-Environment Chamber





The problem:

To physically test crushable materials through a wide range of environments within a single test chamber to determine their energy absorbing capacity. Presently available environmental chambers give data on specimen or assembly behavior due to environmental change but not on physical tests performed through a range of changing environment.

The solution:

A controlled environment chamber that encloses both the test specimen and the devices used to perform the physical tests. The chamber may be stepped through a range of pressures, temperatures, humidities, and chemical atmospheres.

How it's done:

The chamber is firmly mounted on a static test stand so that external forces or movements will not affect it. A ram attached to appropriate force-registering instrumentation is mounted directly above the chamber and enters it through a collapsible, sealing bellows to engage the upper plate of a cubical cavity that contains the specimen under test. The cavity is made up of fixed and movable plates in such a configuration that the ram, pressing on the upper movable plate, will cause deformation of the specimen through lateral expansion. The movable plates, contiguous with the crushable specimen, are spring loaded to maintain intimate contact with the specimen while permitting its deformation under pressure. The chamber is equipped with conduits to introduce heating or cooling gas to the cavity, to raise or lower the pressure within the chamber, or to introduce atmospheres of differing chemical makeup into the chamber.

Instrumentation includes a transducer to measure specimen deformation, thermocouples to monitor

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temperature of specimen and cavity, and a vacuum gauge to monitor chamber pressure.

Notes:

1. Minimal modification would permit other physical tests, such as tensile strength of materials, to be performed as humidity, temperature, cycling, or atmospheres of specific chemical composition and pressure are controlled.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B66-10130

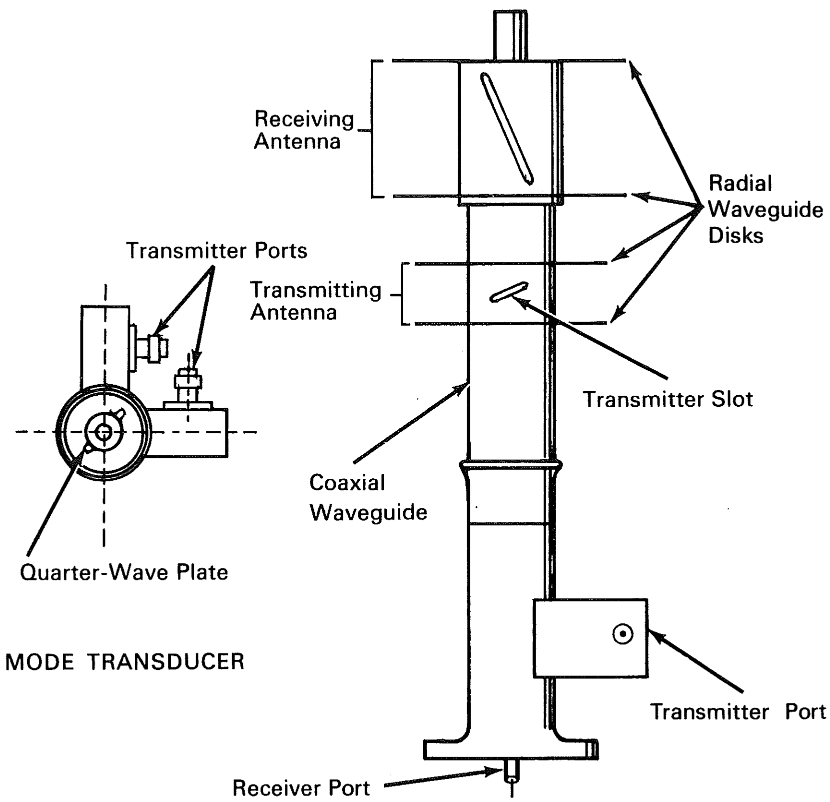
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Albert C. Knoell
(JPL-789)

NASA TECH BRIEF

Omnidirectional Antennas Transmit and Receive Over Large Bandwidth



The problem:
To provide an antenna system capable of exchanging wideband signals between two distant ground stations using satellite airborne equipment as the interconnecting link or relay.

The solution:
Low-gain antennas having wide angular coverage with circular polarization are mounted adjacently on a single mast extending from the satellite. Two decoupled ports or inputs on the transmitting antenna eliminate switching problems when using two transmitters on different frequencies.

How it's done:
The transmitting antenna consists of two major components: the mode transducer and the radiator. The mode transducer consists of two decoupled input ports

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at the base of the antenna and a quarter-wave plate between the two ports and the transmitting antenna. Each input port consists of a short section of rectangular waveguide coupling to the coaxial waveguide through a narrow longitudinal slot cut in the outer conductor of the coaxial waveguide. The coaxial line from a transmitter excites a short probe through the broad face of the rectangular waveguide section. For proper operation, the two ports are oriented at right angles so that the modes excited in the coaxial waveguide will be orthogonal. In addition, the ports are offset longitudinally one guide-wavelength to reduce the direct cross-coupling between ports.

The quarter-wave plate consists of two longitudinal metal ridges attached on opposite sides of the coaxial waveguide inner conductor. The plane of the ridges lies at 45 degrees with respect to the orthogonal input ports. The dimensions of the ridges are adjusted to convert a linearly polarized wave from either of the input ports to a circularly polarized wave traveling toward the radiating section. Ends of the ridges are tapered to prevent reflections.

The radiator consists of eight equally spaced slots cut in the outer conductor of the coaxial waveguide above the quarter-wave plate and a radial waveguide made of two parallel metal disks. The slots are approximately one-half wave in length and are inclined at an angle with respect to the waveguide axis to provide both axial and tangential radiation components. The spacing and diameter of the two disks are adjusted to produce left-hand circularly polarized radiation for excitation of either input port.

The receiving antenna consists of four inclined slots cut in a metal tube and enclosed between two radial disks. This antenna feeds a TEM mode coaxial line extending through the inner conductor of the coaxial waveguide for the transmitting antenna. Right-hand circular polarization is produced by proper adjustment of the disk geometry.

Notes:

1. The probe length and location, the positioning of the shorting plate in the rectangular waveguide, the slot dimensions, and the positioning of the slot from the shorting disk in the coaxial waveguide may be adjusted to provide an impedance match through the transitions of the waveguide.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10133

Patent status:

No patent action is contemplated by NASA.

Source: O. M. Woodward, Jr.
of Radio Corporation of America
under contract to
Goddard Space Flight Center
(GSFC-436)

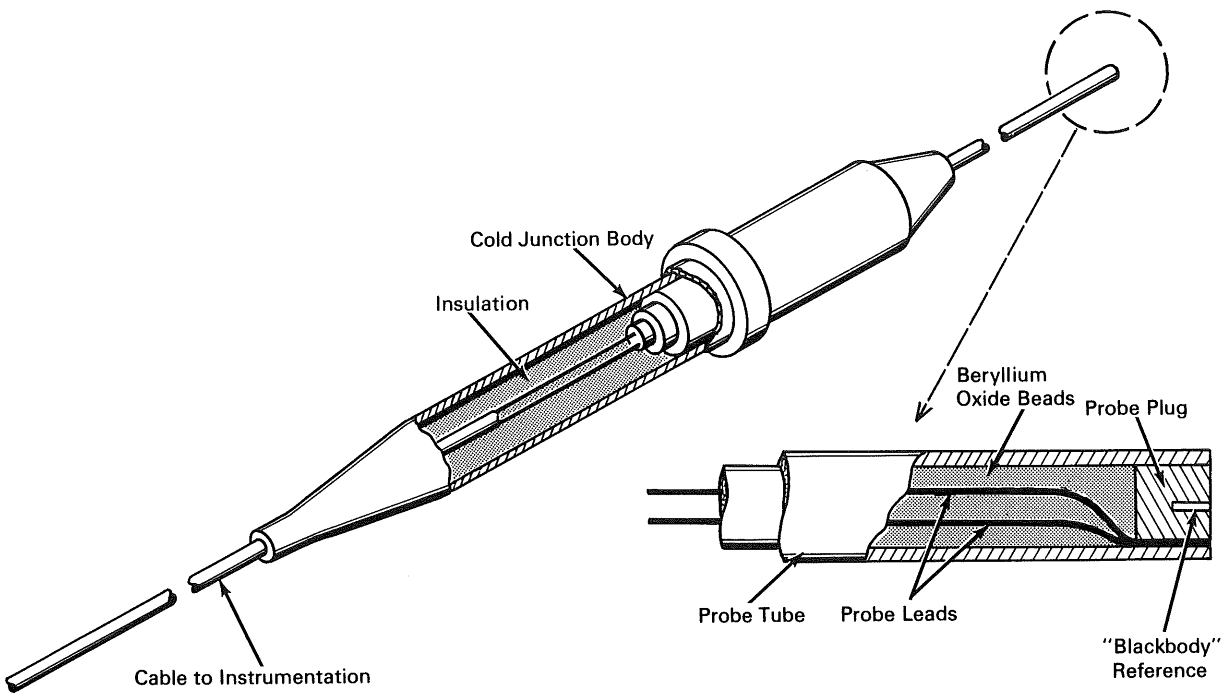
March 1966

Brief 66-10134

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

High Temperature Thermocouple Operates in Reduction Atmosphere



The problem:

To design an instrument for the continuous measurement of a flowing gas up to 4500°F in a hazardous radiation environment.

The solution:

A thermocouple that combines tungsten and rhenium in the probe, housing, and swaged extension lead.

How it's done:

The probe is made of tungsten–5%-rhenium and tungsten–26%-rhenium wire insulated by beryllium oxide beads inside a tungsten–26%-rhenium tube. The sensor junction is formed near the probe tip by a tungsten–26%-rhenium plug that forces the two wires against the side of the tube and electrically shorts them together. The outer end of the plug is fused to form a gastight metallurgical seal as well as a mechanical force-fit hold of the plug. A small hole drilled part way through the plug serves as a blackbody reference for use with an optical pyrometer during furnace calibration.

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Notes:

1. The thermocouple wires extend continuously without splice or foreign material from the cold junction to the probe tip, thus eliminating errors from secondary thermocouple effects.
2. This thermocouple operates over a range of 500° to 4500° F with an accuracy of ±1% at the high end and better than ±1% at the low end.
3. The probe may be used to measure high temperature gases in a non-oxidizing atmosphere with some development, and may be modified for use in an oxidizing atmosphere.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20546
   Reference: B66-10134

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

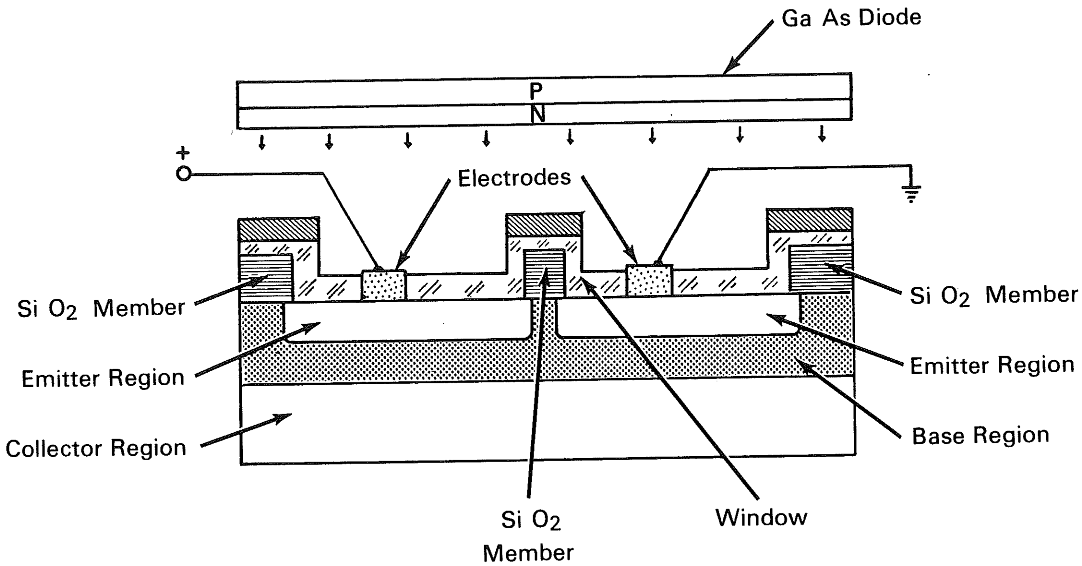
Source: R. G. Hoff, et al
of Aerojet-General Corporation
under contract to
Space Nuclear Propulsion Office
(NU-0046)

April 1966

Brief 66-10141

NASA TECH BRIEF

Optically Driven Switch Turn-Off Time Reduced By Opaque Coatings



The problem:

To reduce the turn-off response time of an optically driven silicon switch. Turn-off time of the switch is lengthened by the absorption of photons by the passivating silicon dioxide members which causes carriers to be trapped or stored in the base region.

The solution:

Place an opaque covering over the passivating silicon dioxide members to prevent photon absorption.

How it's done:

The switch includes a pair of space planar emitter regions set in a base region formed above a collector region. Passivating silicon dioxide members cover those portions of the emitter-base junctions that extend to the upper semiconductor surface. Windows of a suitable transparent material cover the upper surfaces of the emitter regions. Only two small portions that serve as the input and output electrodes of the switch are not covered by the windows.

When a suitable light source, such as a forward biased gallium arsenide diode, illuminates the upper surface of the normally off silicon switch, an electrical circuit is established between the two emitter regions. Removal of the light turns the switch off.

The use of an opaque coating over the silicon dioxide prevents photon absorption so that carriers are not trapped or stored in the surface of the base region, thus materially shortening turn-off response. In the absence of an opaque coating, the turn-off time for the silicon switch is longer than desired for some purposes, being as great as a few milliseconds. When an opaque coating is used, response times on the order of 80 microseconds may be obtained.

(continued overleaf)

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B66-10141

Patent status:

No patent action is contemplated by NASA.

Source: International Business Machines
under contract to
Jet Propulsion Laboratory
(JPL-SC-107)

April 1966

Brief 66-10142

NASA TECH BRIEF

Diffusion Technique Stabilizes Resistor Values

The problem:

To stabilize the values, over a broad temperature range, of resistors used in linear integrated circuits. When several resistors are to be used together in a linear circuit, it is important that they remain as close as possible to their absolute values or that their values vary with temperature in such a manner that the same electrical relationship is maintained. If one resistance of a voltage divider, for example, is in the 10–100 ohm range while the other is several thousand ohms, their proportional variation with temperature or temperature tracking, can be expected to be very poor.

The solution:

Reduce the contact resistance of resistors by P+ diffusion under the alloyed aluminum contacts.

How it's done:

Impurities are introduced into the resistor by P+ diffusion. These impurities offer high conductivity to the region under the aluminum contacts of the resistor, thus reducing contact resistance. The effectiveness of this technique is checked by measuring the reverse breakdown of a base-emitter junction to compare the resistance of a resistor to its geometry after P+ diffusion. A metallographic cross section stained with acid to delineate the junctions shows whether the reduction in contact resistance may be attributed to the P+ diffusion.

Notes:

1. The effectiveness of this innovation has been verified by experiment; it is being used for all small-value resistors in the linear circuits of the Lunar Excursion Module TV camera.
2. Absolute value tolerances of resistors are reduced from ±20% to better than ±10%. A linear amplifier whose voltage gain depends on the linearity and temperature tracking of a 1K ohm:50 ohm resistance ratio was improved from 25% to 3% variation in voltage gain over the temperature range −55°C to +125°C. In general, linearity with voltage polarity change is also improved.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77001
   Reference: B66-10142

Patent status:

No patent action is contemplated by NASA.

Source: Robert C. Gallagher
and Michael N. Giuliano
of Westinghouse Electric Corporation
under contract to
Manned Spacecraft Center
(MSC-205)

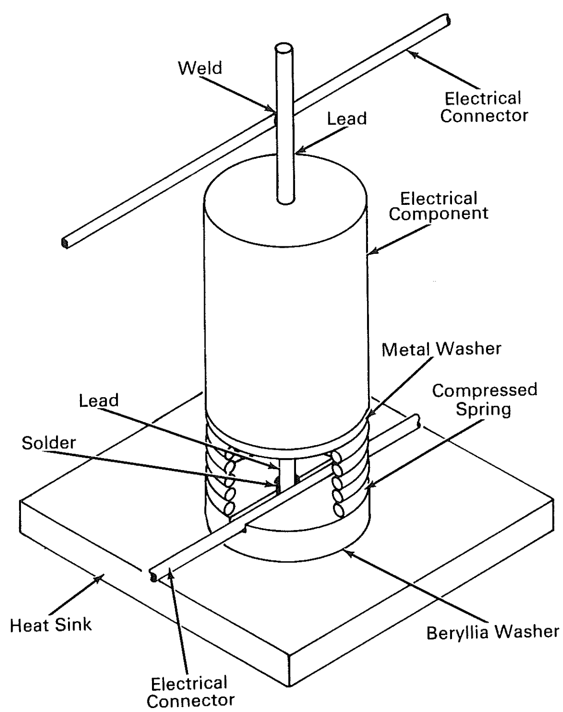
Category 01

April 1966

Brief 66-10144

NASA TECH BRIEF

Mounting Improves Heat-Sink Contact with Beryllia Washer



The problem:

Conducting heat away from electrical components that must be electrically insulated from a metal heat sink. Beryllia (beryllium oxide) washers, which have been used as heat-sink spacers because they combine high thermal conductivity with high electrical resistivity, must be properly mounted to ensure an effective thermal path between the electrical component and the heat sink.

The solution:

Place a metal washer and a coil spring between one end of the electrical component and the beryllia washer mounted on the heat sink.

How it's done:

The beryllia washer containing a metallized cavity (for soldering to the lower component lead) is seated on the heat sink. The lower lead of the electrical component is passed through a snug-fitting hole in a metal washer, and the exposed face of the washer is then placed on a coil spring which has been positioned on the beryllia washer. In mounting the electrical component on the spring sufficient pressure is applied to bring the spring coils into contact when the upper lead is soldered or welded to an electrical connector. The assembly is completed by soldering the lower lead to the cavity in the beryllia washer and to a second elec-

(continued overleaf)

trical connector. Heat transfer to the heat sink is effected through the paths formed by the lower component lead, the base of the component, the metal washer, the compressed spring, and the beryllia washer.

Notes:

1. This method of employing a beryllia washer for heat sinking would be particularly applicable to encapsulated components (e.g., resistors and capacitors) with electrical leads protruding from two ends.
2. The use of indium foil in conjunction with beryllia washers for heat sinking of power transistors is described in NASA Tech Brief B63-10033, April, 1964.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77001
   Reference: B66-10144

Patent status:

No patent action is contemplated by NASA.

Source: Collins Radio Company
under contract to
Manned Spacecraft Center
(MSC-194)

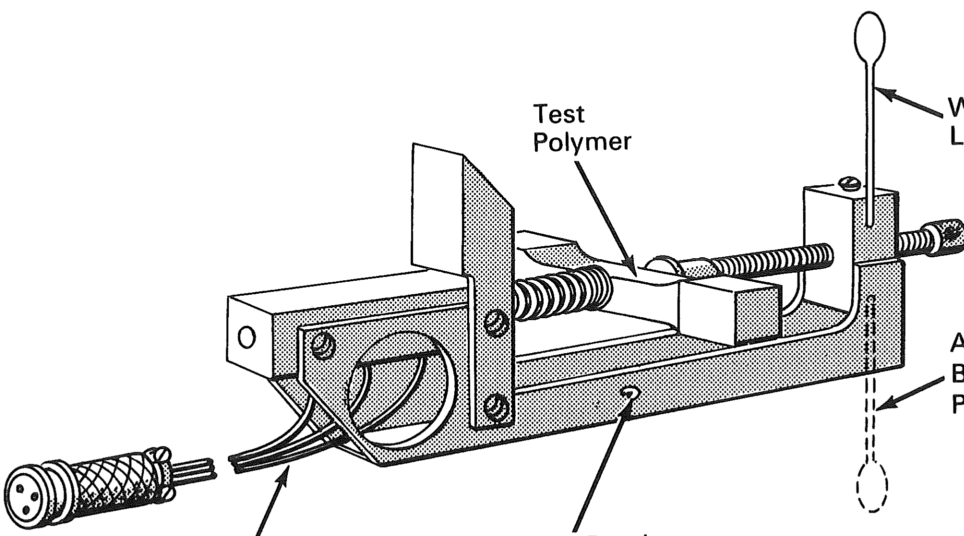
April 1966

Brief 66-10147

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Polymer Deformation Gauge Measures Thickness Change in Tensile Tests



The problem:

To determine the thickness (or cross-sectional) changes undergone by a polymer specimen during the testing of its tensile and elongation properties.

The solution:

A lightweight deformation gauge that remains attached to the specimen throughout testing. This allows continuous measurement of thickness changes with minimum effect on the test specimen.

How it's done:

The gauge body mounts an adjustable screw and a spring-loaded feeler that lightly engage the test specimen. The gauge is suspended from the sample, but because of its light weight, only minimum contact pressure is exerted on the specimen. A transducer attached to the spring-loaded feeler converts any change in specimen cross section into an electrical signal that registers on readout instrumentation. The gauge is finely balanced about the neutral centerline of the test specimen by means of a wire with a lead bead on one end. The wire with lead bead is inserted into a tight hole at one end of the gauge after correct wire length for perfect balance has been determined by trial and error.

If it is desired to measure the thickness of a moving test specimen, a rubberband from the gauge body to a moving platform is used to balance the assembly. The wire with lead bead is placed in the alternate position, shifting the balance point to the center of the rubberband attachment point. In this mode, and suspended from a platform mechanically driven to coincide with

(continued overleaf)

the moving sample, the test specimen is influenced only by the light spring forces needed to overcome the sliding friction of the transducer.

Notes:

1. Mechanical noise from outside sources is dampened when the assembly is hung on a light rubberband.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B66-10147

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Harold H. Broyles and Howard F. Broyles
(JPL-745)

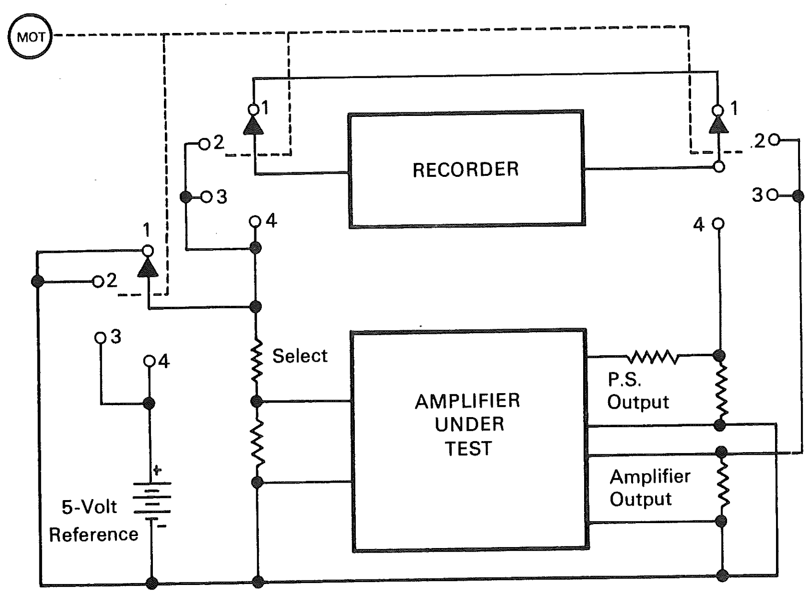
April 1966

Brief 66-10148

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Tester Periodically Registers DC Amplifier Characteristics



The problem:

To provide a device for measuring automatically and periodically the gain and zero drift characteristics of a dc amplifier subjected to changes in environment. Standard industry tests measure the difference between the initial voltage and the voltage that is produced after a period of environmental change. Such methods erroneously assume that an amplifier that performs satisfactorily at the end of an environmental test period has also operated properly while being subjected to changing conditions.

The solution:

A motor-driven switcher-recorder to periodically register zero drift and gain drift error signals.

How it's done:

The motor drives the switches at a chosen rate, for example, one rpm. In the number 1 position, the recorder input terminals are shorted. This position will verify that the recorder zero has not changed. In the number 2 position, the amplifier has no input signal. The recorder will then register the amplifier zero drift. In the number 3 position, a 5-volt signal is applied to the voltage divider. The select resistor is calculated to divide the 5 volts by the same value as the amplifier gain. Therefore, the amplifier output voltage will be 5 volts. The recorder will register zero drift plus gain drift. In the number 4 position, one half of the 10-volt transducer excitation power supply is connected to one input terminal of the recorder while the

(continued overleaf)

other input terminal is connected to the reference 5 volts. The recorder will record one half of the power supply drift.

Notes:

1. Since several measurements are time-shared on a single recorder trace, a time coding method is needed. One method of coding is to have unequal percentages of time for one or more of the measurements. A second coding method is to slightly adjust the different measurement outputs so that the recorder will not read zero, but a known value near zero.

2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77001
   Reference: B66-10148

Patent status:

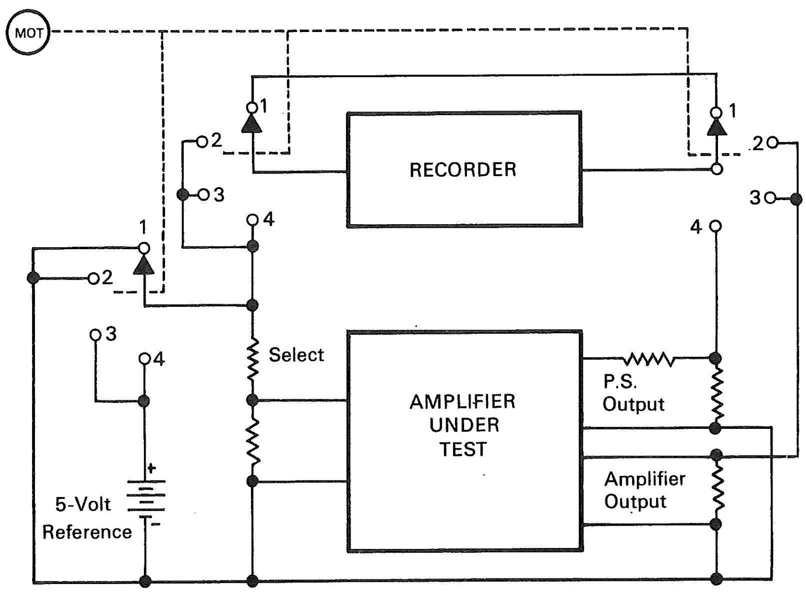
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Guss E. Wenzel and David Cree
(MSC-190)

April 1966 Brief 66-10148

NASA TECH BRIEF

Tester Periodically Registers DC Amplifier Characteristics



The problem:

To provide a device for measuring automatically and periodically the gain and zero drift characteristics of a dc amplifier subjected to changes in environment. Standard industry tests measure the difference between the initial voltage and the voltage that is produced after a period of environmental change. Such methods erroneously assume that an amplifier that performs satisfactorily at the end of an environmental test period has also operated properly while being subjected to changing conditions.

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(continued overleaf)

other input terminal is connected to the reference 5 volts. The recorder will record one half of the power supply drift.

Notes:

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   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77001
   Reference: B66-10148

Patent status:

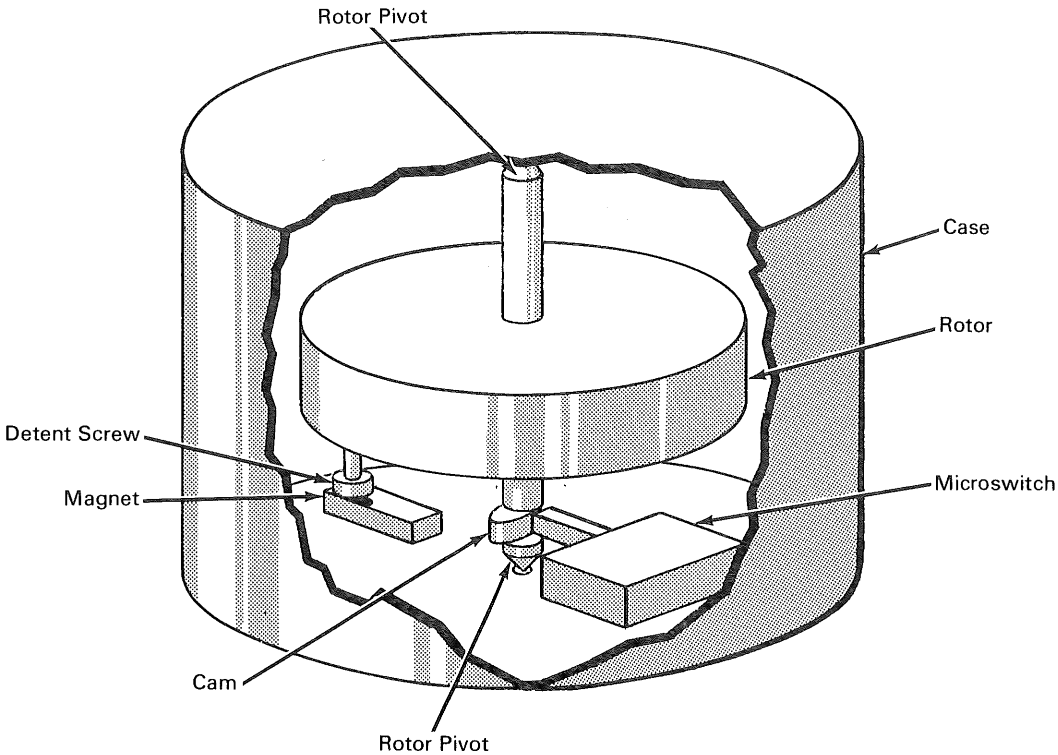
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Guss E. Wenzel and David Cree
(MSC-190)

April 1966 Brief 66-10158

NASA TECH BRIEF

Switching Mechanism Senses Angular Acceleration



The problem:

To design a switching mechanism that will actuate an electrical circuit when a predetermined angular acceleration and displacement are reached.

The solution:

A switching mechanism incorporating a rotor that overcomes the restraint of a magnetic detent when the case in which the detent is mounted reaches the predetermined angular acceleration.

How it's done:

A balanced rotor with a high moment of inertia is mounted on pivots within the case. Rotary motion of the rotor is restrained by the action of the permanent magnet on the detent screw mounted on the rotor, and by the microswitch spring that exerts a centering force on the cam.

When the case of the switch undergoes angular acceleration, the torque acting to accelerate the rotor

(continued overleaf)

is transmitted through the magnetically coupled detent. When the angular acceleration of the case is greater than the angular acceleration produced by the torque acting on the rotor, the case will rotate relative to the rotor. As the relative rotation increases to approximately 6 degrees, the torque transmitted to the rotor decreases to a comparatively low value, because the rotor is no longer restrained by the detent. For the next 104 degrees of relative rotation, the rotor is restrained only by the small force of the microswitch spring. When the relative angular displacement between the rotor and the case reaches 110 degrees, the cam closes the microswitch. After closure, the microswitch will mechanically latch itself in the closed position. The switch can be reset manually by inserting a tool into a special hole in the case of the device.

Notes:

1. The angular acceleration switch is 3 inches in diameter and 7/8-inch high and weighs 0.5 pound.
2. The device will withstand axial sinusoidal vibrations of 25 g between 75 and 125 cps, and 15 g between 125 and 2000 cps.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10158

Patent status:

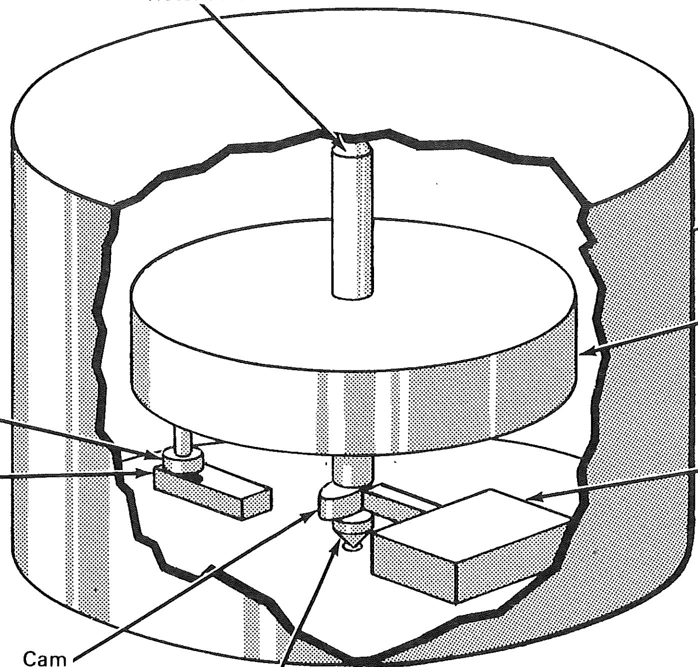
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Ball Brothers Research Corporation
under contract to
Goddard Space Flight Center
(GSFC-462)

April 1966 Brief 66-10158

NASA TECH BRIEF

Switching Mechanism Senses Angular Acceleration



The problem:

To design a switching mechanism that will actuate an electrical circuit when a predetermined angular acceleration and displacement are reached.

The solution:

A switching mechanism incorporating a rotor that overcomes the restraint of a magnetic detent when the case in which the detent is mounted reaches the predetermined angular acceleration.

How it's done:

A balanced rotor with a high moment of inertia is mounted on pivots within the case. Rotary motion of the rotor is restrained by the action of the permanent magnet on the detent screw mounted on the rotor, and by the microswitch spring that exerts a centering force on the cam.

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(continued overleaf)

is transmitted through the magnetically coupled detent. When the angular acceleration of the case is greater than the angular acceleration produced by the torque acting on the rotor, the case will rotate relative to the rotor. As the relative rotation increases to approximately 6 degrees, the torque transmitted to the rotor decreases to a comparatively low value, because the rotor is no longer restrained by the detent. For the next 104 degrees of relative rotation, the rotor is restrained only by the small force of the microswitch spring. When the relative angular displacement between the rotor and the case reaches 110 degrees, the cam closes the microswitch. After closure, the microswitch will mechanically latch itself in the closed position. The switch can be reset manually by inserting a tool into a special hole in the case of the device.

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   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10158

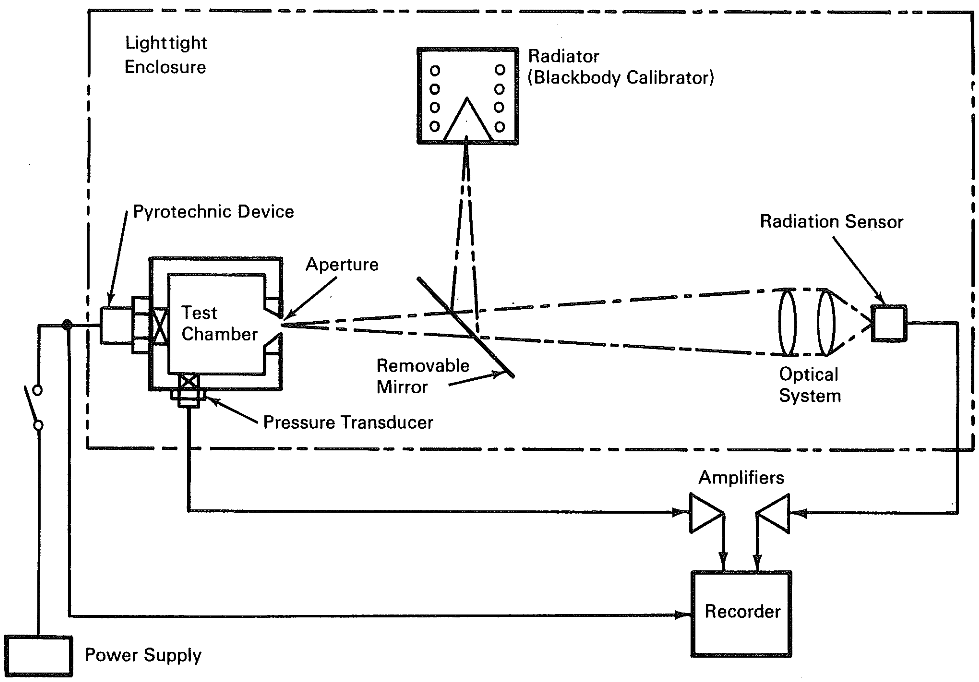
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Ball Brothers Research Corporation
under contract to
Goddard Space Flight Center
(GSFC-462)

NASA TECH BRIEF

Improved System Measures Output Energy of Pyrotechnic Devices



The problem:

To develop a system for measuring the output energy of pyrotechnic devices. Among the methods in present use the most common is the closed bomb test, in which the pyrotechnic device is fired into a chamber of known volume and a pressure versus time record obtained. This method gives insufficient data for a complete analysis and characterization of the significant performance parameters of the pyrotechnic device.

The solution:

A system that discharges the reaction products of the pyrotechnic device into a chamber and measures the radiant heat output from a pinhole aperture as well as internal pressure changes on a common time base.

How it's done:

The test chamber, a cylinder with a unity diameter-to-length ratio, is designed to have the least practicable surface area in proportion to volume in order to minimize heat losses. The chamber is constructed of stainless steel of sufficient thickness to provide an effectively infinite thermal mass to further minimize heat losses during the burning time of the pyrotechnic device. The finish of the interior surface of the chamber has a value of at least RMS 63 to ensure a high

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albedo. A replaceable pinhole aperture is located in the chamber wall opposite to the port through which the pyrotechnic discharge is admitted. The aperture size is as large as possible consistent with minimum pressure drop.

A suitable radiation sensor is positioned outside of the chamber opposite to the pinhole orifice to receive the radiant heat energy from a firing of the pyrotechnic device. The pressure transducer, a strain gage type with a flush diaphragm, is located in a side wall of the chamber.

Outputs from the radiation sensor and pressure transducer, as well as ignition current and voltage versus time, if desired, are applied to a multiple trace oscilloscope and recorder. The entire system is mounted in a ventilated, lighttight enclosure. The inner surface of the enclosure and exteriors of the system components are finished in a flat-black nonreflective coating.

Before beginning a test, the system is calibrated by heating a radiator to a known temperature. The infrared radiation emitted is reflected by a mirror through the optical system and focused on the radiation sensor, thus producing an output signal proportional to radiation output, which may be recorded. The mirror is then removed and the pyrotechnic device is fired.

The pressure produced by the products of combustion of the pyrotechnic components is sensed by the pressure transducer, and the electrical output corresponding to the pressure changes is displayed on the recorder. The heat produced by the pyrotechnic reaction is reflected by the interior walls of the chamber and emitted through the aperture. The optical system focuses this radiation on the radiation sensor, which provides an output to the recorder.

Notes:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California, 90406
Reference: B66-10159

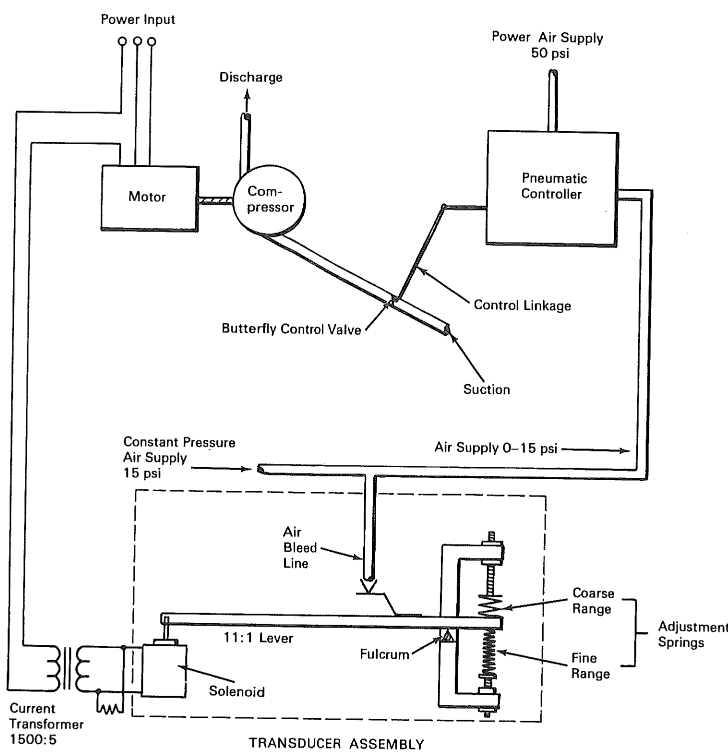
Patent status:

No patent action is contemplated by NASA.

Source: Edgar M. Shortly
of North American Aviation, Inc.
under contract to
Western Operations Office
(WOO-256)

NASA TECH BRIEF

Electropneumatic Transducer Automatically Limits Motor Current



The problem:

To provide a device for limiting current input to an electric motor to a predetermined maximum by automatically adjusting the motor loading. A simple, efficient, and inexpensive method is required to limit the current input to an electric motor driving a centrifugal freon compressor in a water cooling system.

The solution:

A pneumatic controller regulates the load on the compressor, thus limiting motor input current. The pneumatic controller receives an air signal by means of an electromechanical transducer monitoring the motor input current.

How it's done:

The motor current controller consists of three sections, the motor/centrifugal compressor unit, the transducer assembly, and the pneumatic controller and associated linkage. The 1500:5 current transformer applies a current to the solenoid proportional to the input current of the motor. As the input current increases, the solenoid depresses the lever that causes a proportionate increase in the amount of air bled

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itance is measured with a circuit employing a high-gain amplifier in a feedback loop with the probe. This circuit provides a voltage output that is directly proportional to the capacitor plate separation and hence to the applied force.

Notes:

1. This transducer can be used in high-pressure as well as in low-pressure environments for static and dynamic force measurements.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B66-10161

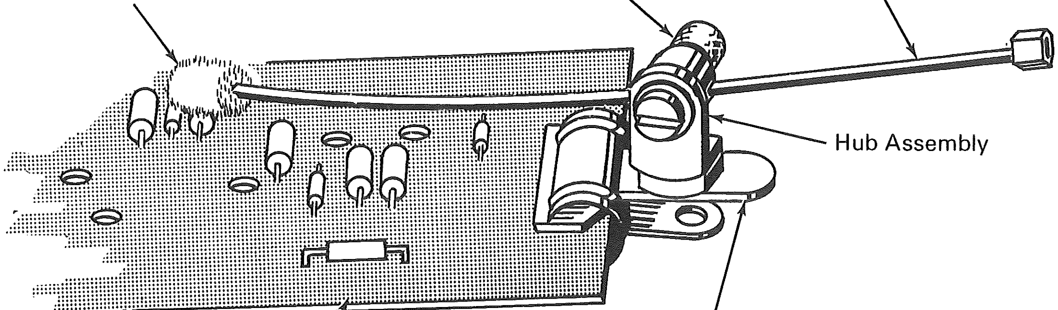
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Dean Carlton Glenn
(Lewis-218)

NASA TECH BRIEF

Fixture Aids Soldering of Electronic Components on Circuit Board



The problem:

To design a fixture that will hold small electronic components in the desired position while they are being soldered on a circuit board. Common methods of holding components in position include the use of friction tape, bending of component leads, and application of finger pressure, all of which are often unsatisfactory.

The solution:

A fixture incorporating a spring clamp that is clipped on the edge of a circuit board and an adjustable spring-steel boom that holds components against the board.

How it's done:

The spring clamp, with felt attached to the clamping jaws to prevent damage to the circuit board, provides a base for the fixture. The spring-steel boom, padded at the end which will exert pressure on the component to be soldered, slips through a slot in a hub assembly mounted on an angle bracket. Friction mounting of the bracket and hub assembly permits the boom to be rotated about two mutually perpendicular axes (one axis in a horizontal plane and the other in a vertical plane) to apply holding pressure to any component within the radius of the boom. The working radius of the boom can be adjusted by slipping the boom through the slot in the hub assembly.

Notes:

1. The felt pad on the end of the boom can be replaced with different attachments for other holding tasks.
2. Inquiries concerning this invention may be directed to:
   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B66-10162

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

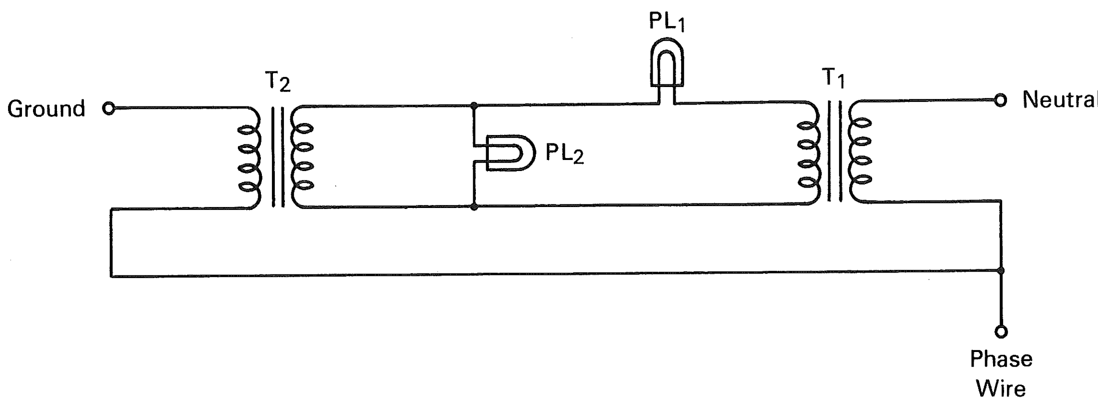
Source: Milton H. Ross
(ARC-56)

April 1966

Brief 66-10163

NASA TECH BRIEF

Two-Light Circuit Continuously Monitors AC Ground, Phase, and Neutral Wires



The problem:

To provide a means of monitoring the continuity of the ground, neutral, and phase wires of an ac circuit. Redundant ground straps used to insure proper grounding have no monitor, can constitute safety hazards, and give no indication if either the phase or neutral lines should become open-circuited.

The solution:

A two-transformer, two-lamp circuit designed to give different visual indications if any one of the three lines is open-circuited.

How it's done:

The circuit consists of two transformers and two pilot lamps wired as shown. With all circuits connected and performing properly, pilot lamp PL_2 should be illuminated and PL_1 should be off. The primary of T_2 is energized by current from the phase wire to the ground wire, thus energizing the secondary of T_1 in phase with the secondary of T_2. PL_1 will not be illuminated since there is no difference in potential across its terminals.

A loss of the ground wire will de-energize T_2 and PL_2 will go off. T_1 secondary is still energized, thus illuminating PL_1. The ac impedance of the secondary of T_2 is much less than that of PL_2, hence PL_2 will remain off.

A loss of the neutral wire will de-energize T_1, allowing the secondary of T_2 to energize both PL_1 and PL_2 since they are in parallel with respect to T_2.

A loss of the phase wire will de-energize all circuits and extinguish both lights.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas, 77001
Reference: B66-10163

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

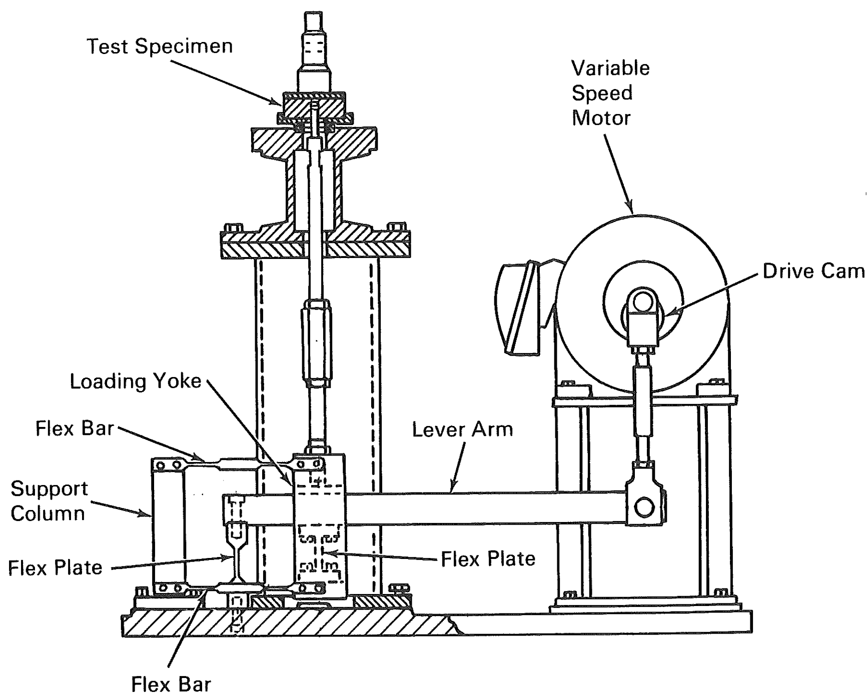
Source: R. W. Mee
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-356)

April 1966

Brief 66-10164

NASA TECH BRIEF

Fatigue Tester Achieves True Axial Motion Through Flex Plates and Bars



The problem:

To design an inexpensive lever load-amplifying fatigue testing machine with a load cycle frequency of 100 to 900 cycles per minute that will apply the load through true axial motion. Pivot friction and bearing wear introduce inaccuracies in present devices.

The solution:

A tester that replaces pivots and bearings with flex plates and bars to achieve true axial motion.

How it's done:

A variable speed motor and commercially available cam operate the lever arm. The arm applies an axial load to the specimen under test through two frictionless flex plates, one to take the place of the usual knife blade pivot, and the other to take the place of the usual bearing on the load bar. Parallel flex bars link a loading yoke and the flex plates with a support column to achieve true axial motion of the load against the test specimen.

(continued overleaf)

Notes:

1. In this design, a load amplification ratio of 5 to 1 has been obtained.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Reference: B66-10164

Patent status:

No patent action is contemplated by NASA.

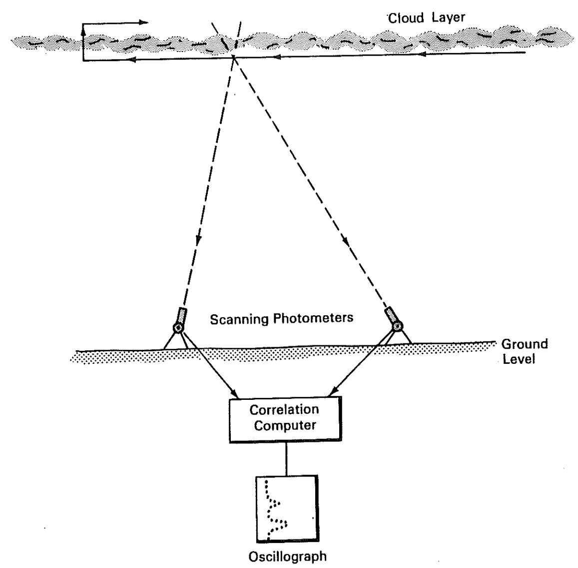
Source: C. D. Kurinko and T. F. Hengstenberg
of Westinghouse Astronuclear Laboratory
under contract to
Space Nuclear Propulsion Office
(NU-0021)

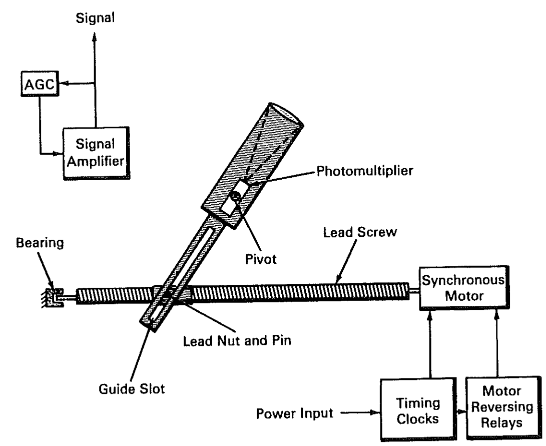
April 1966

Brief 66-10170

NASA TECH BRIEF

Scanning Photometer System Automatically Determines Atmospheric Layer Height





The problem:

To determine the height of nonuniform luminous layers above the earth, such as clouds or airglow. Present systems use a vertical beam of modulated light whose reflection is seen by a telescope and photocell located a discrete distance from the light source. Separate calculations are required to determine the height of the reflection and scanning is not automatic.

The solution:

A pair of photometers, placed a given distance apart, that scan the luminous layers in a synchronous manner. Photometer outputs are correlated by a simple analog correlation computer to automatically give luminous layer height.

How it's done:

The photometers are placed a distance apart determined by the height of the layers to be investigated and are mechanically driven so that the point of intersection of their fields of view moves in a horizontal line. After completing one scan, they move to a higher level and scan again. Scanning is repeated up to the maximum desired height.

As shown in the right-hand figure, each photometer is caused to move about its pivot by motion of the lead nut along the lead screw and motion of the pin in the guide slot. The photometers are driven by identical synchronous motors so that the intersection of their fields of view moves in a horizontal line at con-

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stant speed. At the end of each scan the motors are reversed.

To raise the scan height, either the left motor is run for a short period to pivot its photometer to the left, or the right motor to pivot its photometer to the right. To lower the scan height, either motor is run for a short period to bring its photometer's field of view directed more towards the other instrument.

Notes:

1. This system could be used to determine visibility ceilings at airports.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77058
   Reference: B66-10170

Patent status:

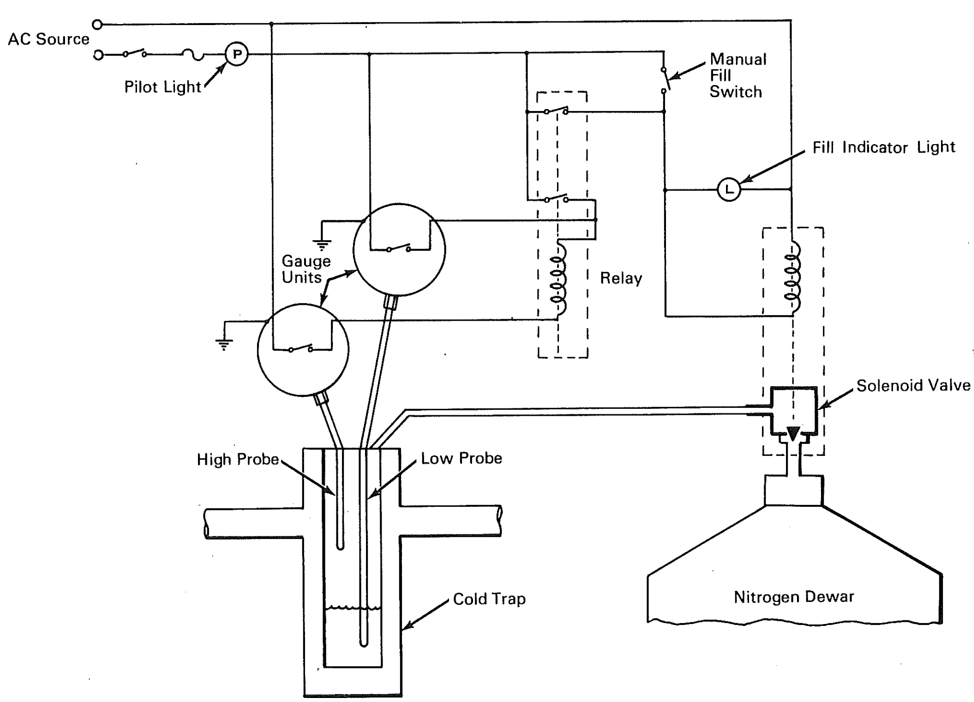
No patent action is contemplated by NASA.

Source: Milo Wolff
of Massachusetts Institute of Technology
under contract to
Manned Spacecraft Center
(MSC-245)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Charged Probes, Bourdon Tubes Maintain Cryogenic Liquid Level



The problem:

To design a system that automatically maintains the fluid level in a liquid nitrogen cold trap. It is frequently necessary to operate a vacuum system using one or more cold traps for a prolonged period with the cold trap liquid level maintained between set limits. Electronic devices have been subject to failure due to the effect on components of cryogenic temperatures.

The solution:

An automatic liquid nitrogen dispensing system that uses gas filled probes, driving Bourdon tube gauges equipped with microswitches that, through a relay, control a solenoid valve in the liquid nitrogen storage line.

How it's done:

The system is comprised of two probes that are in essence gas-filled (dry nitrogen) capillary tubes, the ends of which are inserted into a cold trap or liquid nitrogen reservoir at different depths. The vertical distance between the ends of these probes will govern the length of the fill cycle. When the level of nitrogen drops below the lower probe, its internal pressure rises causing the Bourdon tube in

(continued overleaf)

the gauge unit to close a microswitch that energizes an electrically latching relay. When the level of nitrogen rises to that of the second gas filled probe, another switch operates to break the current to the relay, thus unlatching it. This relay controls the solenoid valve in the liquid nitrogen transfer tube. The self-sustaining nitrogen transfer tube is made of brass in order to introduce an intentional heat leak path into the supply dewar. This creates a sufficient pressure differential to achieve fluid transfer when the solenoid valve opens.

Notes:

1. The system is fail-safe since loss of a probe gas charge will automatically open its gauge-switch unit to deactivate the relay.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio, 44135
   Reference: B66-10109

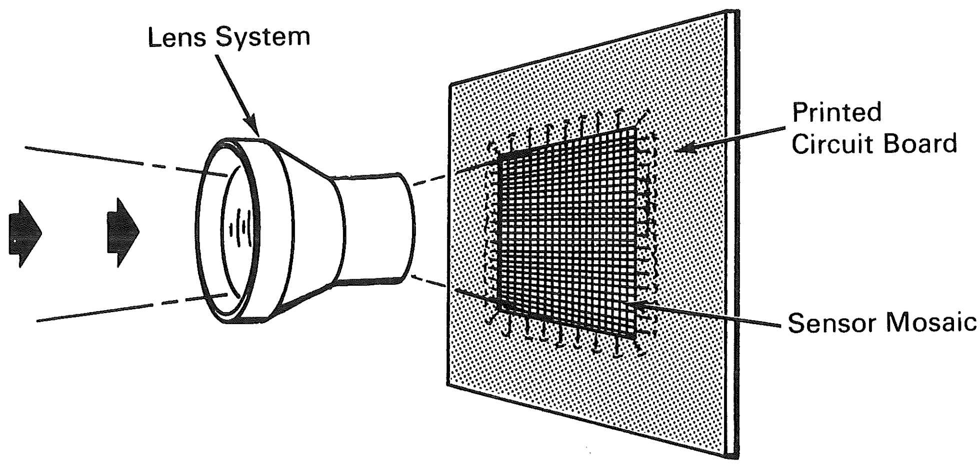
Patent status:

No patent action is contemplated by NASA.

Source: Mylo J. Krejsa
(Lewis-261)

NASA TECH BRIEF

New Television Camera Eliminates Vidicon Tube



The problem:

To design a highly reliable television camera of reduced size, weight, and power consumption.

The solution:

A camera system that uses a solid state imaging device in the form of a phototransistor mosaic sensor instead of a vidicon tube for light sensing and image conversion.

How it's done:

The sensor is a square mosaic made up of 2,500 phototransistors with 50 light-sensitive semiconductor elements on a side. Each element is composed of a 3-layer phototransistor controlling its own current which is modulated by the light striking it. Each phototransistor has an independent base region, with the emitters interconnected by evaporated aluminum strips in 50 isolated columns. Readout is accomplished by applying voltage to a 50-element collector strip and sequentially commutating the rows of emitter elements so that one element is read at a time with all other elements cut off. Fifty emitter follower amplifiers in the emitter element readout circuitry enhance camera sensitivity by providing high input impedance to each element and low output impedance for the switching circuit.

Flip-flop binary logic provides the pulse sequence for mosaic multiplexing by pulsing the emitter readout switches, by applying voltage pulses to the collector strips, and by synchronizing the horizontal and vertical sawtooth generators for the monitor.

Notes:

1. The camera uses a standard 16-mm lens, measures 6 x 4 x 3½ inches in size, and requires 4 watts of power.
2. The digital logic circuits scan the sensor mosaic at 60 frames per second to produce pictures composed of a series of dots rather than lines.

(continued overleaf)

3. The 5-Mc video bandwidth signal can be transmitted over commercial telephone lines.
4. Inquiries concerning this invention may be directed to:

    Technology Utilization Officer
    Marshall Space Flight Center
    Huntsville, Alabama, 35812
    Reference: B66-10112

Patent status:

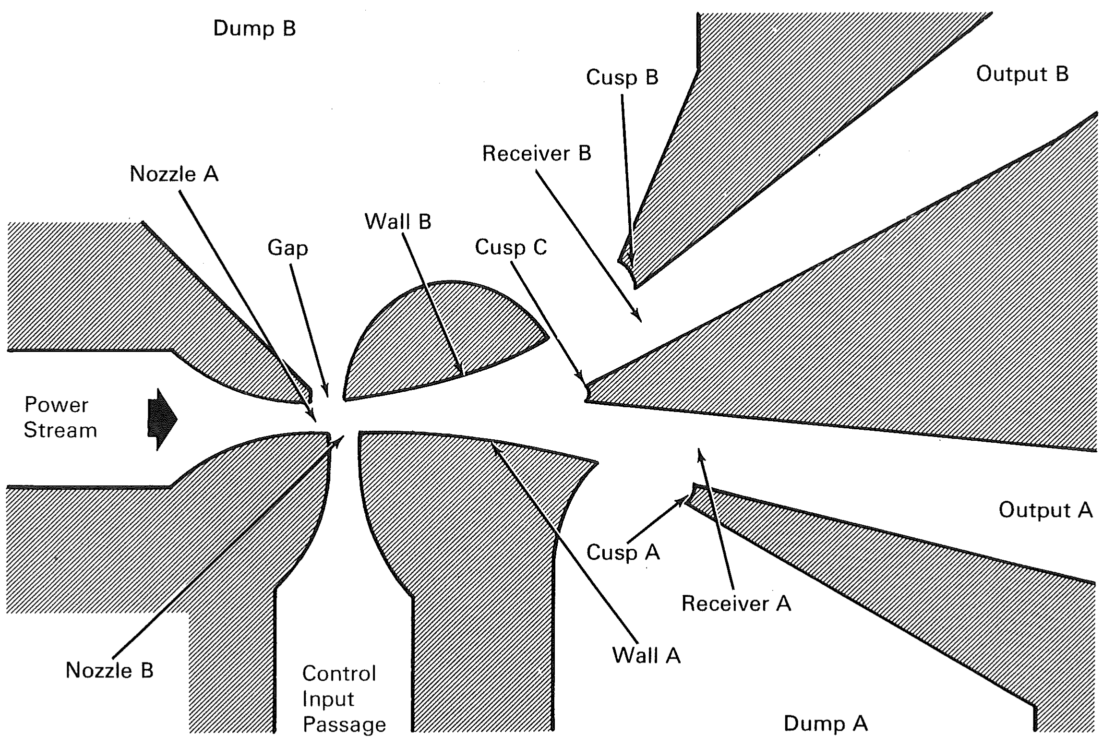
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Westinghouse Electric Corporation under contract to Marshall Space Flight Center (M-FS-472)

May 1966 Brief 66-10177

NASA TECH BRIEF

Binary Fluid Amplifier Solves Stability and Load Problems



The problem:

To design a digital fluid amplifier with the characteristics of load insensitivity, high stability, and the capability of operating at low Reynolds numbers.

The solution:

A fluid amplifier with specially designed nozzles to provide uniform exit-velocity profiles and to ensure jets of low turbulence.

How it's done:

A continuous supply of working fluid (e.g., air) issues from power nozzle A. A control signal, which would normally be the output from another fluid device, may be applied through the control input passage to emerge as a jet from nozzle B. When no control flow is present, the jet from power nozzle A follows the curvature of wall A and enters receiver A. When control flow is present, the power jet is forced away from wall A to wall B. The power jet then follows the curvature of wall B and enters receiver B. Receivers A and B lead to passages that supply fluid to the control nozzles of other fluid state elements or sensors. Surplus fluid is vented to a low-pressure

(continued overleaf)

manifold via dumps A and B. Cusps A and B allow a relatively noise-free "peeling off" of the surplus air not required by the fluid devices attached to outputs A and B. A gap opposite the control input passage allows for entrainment of low-pressure manifold fluid and permits the power jet to detach from wall B when the control signal from nozzle B is removed. Cusp C enhances the bistability of the power jet by creating a vortex that inhibits flow into the two receivers simultaneously.

The design of nozzles A and B and the curvature and location of walls A and B are such that under conditions of zero flow through the control input passage, the pressure in this passage is equal to the pressure in the return manifold (or the environment in an open system). Similarly, under conditions of normal operation in a binary circuit, the flow in outputs A and B is zero when the pressure in these outputs is equal to the pressure in the return manifold.

Notes:

1. When the outputs are blocked, the performance of the device is unaffected; there will be control pressure at one output and low pressure (manifold pressure) at the other.
2. The design is such that outputs A and B may drive one fluid state element each. Since relatively low gain is utilized, the device has low sensitivity to dirt in the fluid supply or to slight variations in element geometry. This feature lends itself well to the concept of integrated circuits in which many elements are formed in a single sheet of material.
3. Since the device utilizes no techniques that depend on the presence of a turbulent boundary layer or even on turbulence in general, its performance is satisfactory at low Reynolds numbers. There appears to be no upper limit to the Reynolds number at which the device will operate.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Electronics Research Center
   575 Technology Square
   Cambridge, Massachusetts, 02139
   Reference: B66-10177

Patent status:

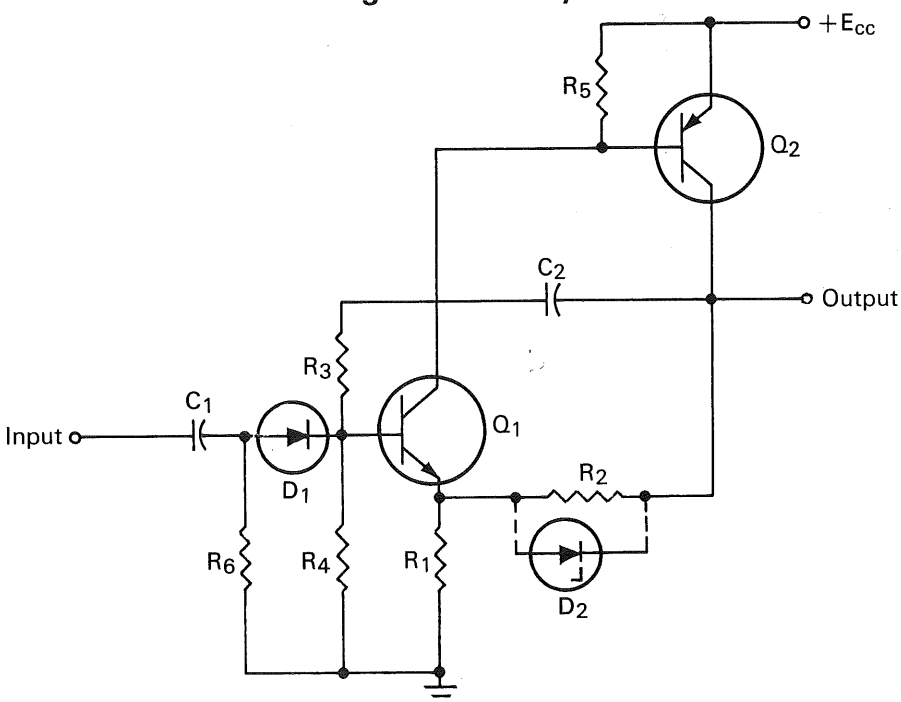
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Babette D. Larkin and T. D. Reader
of Giannini Controls Corp.
under contract to
Electronics Research Center
(ERC-15)

May 1966 Brief 66-10179

NASA TECH BRIEF

Complementary Monostable Circuits Achieve Low Power Drain and High Reliability



The problem:

To design a complementary monostable multivibrator having minimum power dissipation and maximum reliability.

The solution:

A two-transistor multivibrator that minimizes the use of components that are subject to environmental change or other unpredictable behavior. The circuit has virtually no power drain in standby operation.

How it's done:

The two transistors are normally off in the absence of a biasing network to turn them on. When a positive trigger pulse is applied to the input coupling network (C_1, R_6, D_1), both transistors turn on. Positive regeneration occurs because the input trigger pulse is amplified by the forward voltage gain $[1 + R_2/R_1]$ of the circuit and fed back through C_2 to the base of Q_1 in phase with the input trigger pulse. If the attenuation of the amplified trigger pulse, approximately equal to $[R_4/R_3 + R_4]$, is small, regeneration is rapid. Q_2 is driven to saturation by Q_1. Regeneration will take place if $[1 + (R_2/R_1)]\,[R_4(R_3 + R_4)] > 1$.

As C_2 begins to charge, the base voltage of Q_1 decreases exponentially until Q_2 comes out of saturation. Negative regeneration then occurs and the circuit

(continued overleaf)

turns off. The base voltage required to remove Q_2 from saturation is approximately the supply voltage divided by the forward gain $[E_{cc}/(1 + R_2/R_1)]$. In effect, a negative resistance of magnitude $[-R_1R_3/R_2]$ appears in parallel with the input impedance seen at the base of Q_1. If the resultant impedance is negative, switching takes place.

The output pulse width may be varied by changing the forward gain $[1 + R_2/R_1]$. The width may be changed by a factor of ten or more by varying R_2. Temperature compensation is obtained by inserting the proper thermistor in series with R_1.

Notes:

1. By placing a zener diode across R_2, the effects of power supply and beta variations are made negligible. The operation is the same as described above until the voltage across R_2 reaches the zener voltage, E_Z. At this time the forward gain is unity and regeneration ceases. Both Q_1 and Q_2 are then operating on the linear portion of their characteristic curves, provided the supply voltage is greater than $E_z (1 + R_4/R_3)$. The input impedance is now β^2R_1. When the zener diode conducts, the voltage across R_3 and C_2 remains constant. The current through R_4 is essentially the current through R_3 and C_2, and is decreasing exponentially. When the current through R_1 decreases to where the zener can no longer conduct, negative regeneration takes place and the circuit turns off.
2. This circuit exhibits high rejection of spurious triggers, is easy to design, is capable of pulse widths of 0.5 microsecond, is easily temperature compensated, and has an easily controlled output width. It is, however, limited to low duty cycles. The addition of the zener diode makes the output pulse width independent of beta.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10179

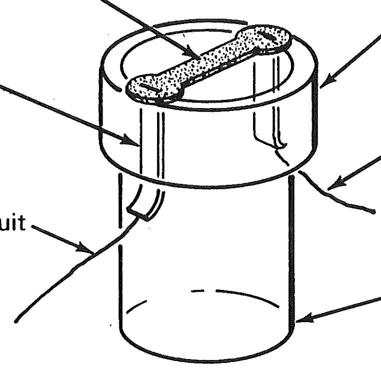
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Leonard L. Kleinberg and
Richard C. Lavigne
(GSFC-433)

NASA TECH BRIEF

Thin-Film Gage Measures Low Heat-Transfer Rates



The problem:

To measure low heat-transfer rates (less than 2 Btu/ft^2/sec) in order to determine the transition between laminar and turbulent conditions in the boundary layer surrounding slender and moderately slender cones under test in a hypersonic blowdown helium tunnel. The low heat-transfer rates create a measurement sensitivity problem and preclude the use of thermocouples.

The solution:

A heat-transfer gage consisting of a thin layer of vacuum-evaporated platinum, which acts as a resistance thermometer, on a heat-resistant glass substrate that is contoured to fit the model surface.

How it's done:

Close-fitting pieces of the glass tubing and rod, with two diametrically opposed platinum foil strips embedded between them, are fused together to form the substrate. The substrate is ground and polished to fit the model on which it is to be installed. The thin platinum resistance element is then vacuum-evaporated onto the substrate across the exposed ends of the embedded platinum strips. The gage is then calibrated and installed in the model. When the gage is connected as the active arm of a bridge circuit it produces a voltage proportional to the temperature of the glass surface.

Notes:

1. The gage has a wide dynamic range and a rapid response time.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia, 23365
   Reference: B66-10180

Patent status:

No patent action is contemplated by NASA.

Source: Cary R. Spitzer
(Langley-205)

Category 01

NASA TECH BRIEF

Subminiaturized Gas Chromatograph Gives Fast, Efficient Analysis

The problem:

In gas chromatography, there are many commercially available devices that, together, can analyze a wide range of gases. For space applications, these devices pose serious weight problems because of the large amounts of carrier gas they must dissipate in effecting an analysis. Additionally, it is desirable to analyze the gases more rapidly than the typical 5 to 10 minutes required of prior art.

The solution:

A subminiaturized gas chromatograph weighing only 100 grams and capable of analyzing samples in a few seconds with a carrier gas flow of one milliliter per minute.

How it's done:

A one-microliter gas sample is injected with the carrier gas into a subminiaturized column (microcolumn) where the selective absorption of the constituents by the column packing causes characteristic delays in traversal time, thus separating the constituents. The column is packed with fine-grain (25-micron) particles of uniform size that are held in place by electronically machined, sintered stainless-steel plugs that allow the gas to pass through while retaining the particles. The small volume of gas from the microcolumn is passed through a subminiature detector that compares the conductivity of the carrier gas and sample with that of the carrier gas alone in separate chambers. Each chamber is equipped with a platinum–rhodium thermal conductivity element hot wire 0.012-inch long and 10^{-5}-inch in diameter, each forming half of a ratio arm of a Wheatstone bridge. Chamber volume is 0.1 microliter and power drain is only 0.5 milliwatt.

Notes:

1. A microcolumn three inches long will separate certain compound constituents in one second with a carrier gas flow rate of only one milliliter per minute. A typical prior art column would be 10 feet long, require a carrier gas flow rate of 60 milliliters per minute, and require 10 minutes to effect the same separation.
2. In extraterrestrial exploration, the system could be used with a mass spectrometer for the detection of life-supporting compounds.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California, 91103
   Reference: B66-10182

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: W. F. Wilhite
(JPL-735, 736, 737, and 740)

Category 01

May 1966 Brief 66-10192

NASA TECH BRIEF

Coating Permits Use of Strain Gage in Water and Liquid Hydrogen

The problem:

To provide a protective coating that will permit a strain gage to be used for making measurements in water and subsequently in liquid hydrogen. Previously, no single strain gage installation could be satisfactorily used in both environments.

The solution:

A strain gage installation consisting of a selected foil strain gage bonded with a modified commercial heat-curing epoxy cement and covered with a three-layer coating of commercially available protective materials.

How it's done:

The surface on which the gage is to be mounted is first subjected to a thorough cleaning and abrading treatment. A drop of distilled water will flow freely on a properly prepared surface.

A 1-mil precoat of a modified heat-curing epoxy resin is applied to the prepared surface and allowed to dry for 4 hours. A 1-mil coat of this resin is applied over the precoat, and the gage and tabs are positioned on the coated surface. The installation is then cured for 4 hours at 225° F under 5 psi clamping pressure. Leads from Teflon-insulated wires are soldered to the tabs. A small dab of the epoxy resin is used to bond the lead wires to the test specimen.

A 1-mil coat of a flexible nitrile rubber is brushed over the entire gage and tab area and over the lead wires. This coat is allowed to dry for 15 minutes. A 1-mil coat of a quick-drying resin is applied over the same area and allowed to air-dry for 15 minutes. The last step in the installation procedure is to apply a thin coat of a silicone waterproofing lacquer over the air-dried resin.

Notes:

1. When the gage installation is immersed in liquid hydrogen, the outer silicone lacquer protective layer may develop cracks, which will destroy its waterproofing characteristics. Therefore, when the gage is to be used for strain measurements in water and in liquid hydrogen, the measurements in water must take precedence.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10192

Patent status:

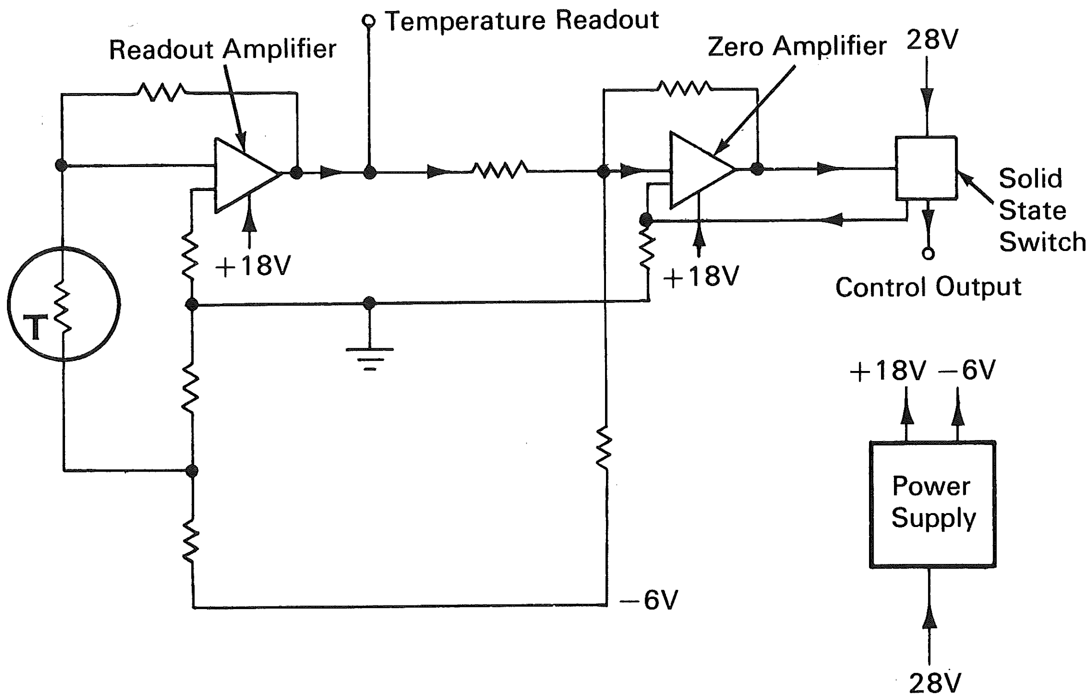
No patent action is contemplated by NASA.

Source: B. B. Berven
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-594)

Category 01

NASA TECH BRIEF

Solid State Thermostat Has Integral Probe and Circuitry



The problem:

To develop a rugged, reliable thermostat without moving parts that will provide a temperature readout signal and a continuous temperature-control output for monitoring the temperature by automatic check-out equipment or telemetry systems. The readout signal must lie in the range from 0.5 volt (0°C) to 5 volts (50°C), and temperature control must be maintained within ±0.2°C in the range from 25° to 50° C.

The solution:

A compact thermostat employing a thermistor probe and a solid state circuit mounted in a housing rigidly attached to the probe.

How it's done:

The thermostat consists of five functional units: a thermistor temperature-sensing element, a readout amplifier, a zero amplifier, a solid state switch, and a power supply. The circuit uses 13 transistors and 6 semiconductor diodes. The probe, which houses and protects the thermistor, is hermetically sealed and employs a copper tip to ensure good heat transfer to the thermistor. The thermistor, which is connected to a source of constant voltage, has a high impedance to minimize self-heating and consequent error signals. This thermistor forms the temperature-varying input resistance to the readout amplifier. The output voltage

(continued overleaf)

from this amplifier, which is dependent on the temperature sensed by the thermistor, is used as the temperature readout signal and as the input signal to a preselected resistor network where the signal is compared to a reference voltage derived from the power supply. Any deviation of the readout voltage from a preset reference voltage is detected and amplified by the zero amplifier. The output of this amplifier is applied to the solid state switch connecting the heating load to the 28-volt line.

The power supply, which operates from a 28-volt source, provides two regulated voltages, 18 volts and –6 volts. The 18-volt line supplies the amplifiers, and the –6 volt lines serves as a reference for both the readout amplifier and the zero amplifier.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama, 35812
Reference: B66-10193

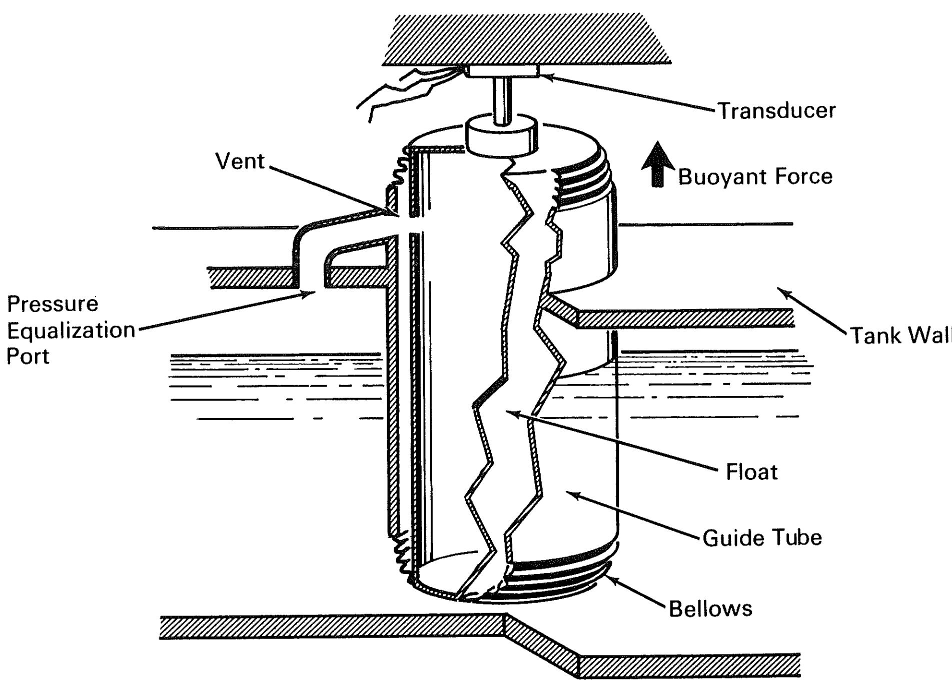
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C., 20546.

Source: MetroPhysics, Inc.
under contract to
Marshall Space Flight Center
(M-FS-434)

NASA TECH BRIEF

Device Without Electrical Connections in Tank Measures Liquid Level



The problem:

To measure the liquid level in a tank without any electrical connections inside the tank. The level-measuring system must be insensitive to tank pressure and temperature changes.

The solution:

A vertical static float in the tank that transmits the buoyant force of the liquid to an external force transducer.

How it's done:

The static float is housed inside of a guide tube which is welded to the tank wall. The float is held in the guide tube by means of isolating bellows at the top and bottom. The force transducer is mounted above and in contact with the upper bellows.

Since the float is displaced only a small amount equal to the displacement of the force-summing member of the transducer, the level of the liquid in the tank is proportional to the buoyant force acting on the float, which is transmitted to the transducer. The transducer is connected in an electrical circuit which gives an output signal proportional to the liquid level.

The lower bellows has a spring rate at least an order of magnitude less than that of the upper bellows. This difference in spring rates is to allow the thermal expansion of the float to be in the downward direction rather than against the transducer.

(continued overleaf)

Notes:

1. The internal components of this device can be made of materials that will be compatible with various liquids over a wide range of operating temperatures. The device is insensitive to tank pressure, and since it has essentially no moving parts, it can be used where high reliability and longevity are necessary.
2. The static float could also be connected to a dial indicator when a visual indication of liquid level is desired.

Patent status:

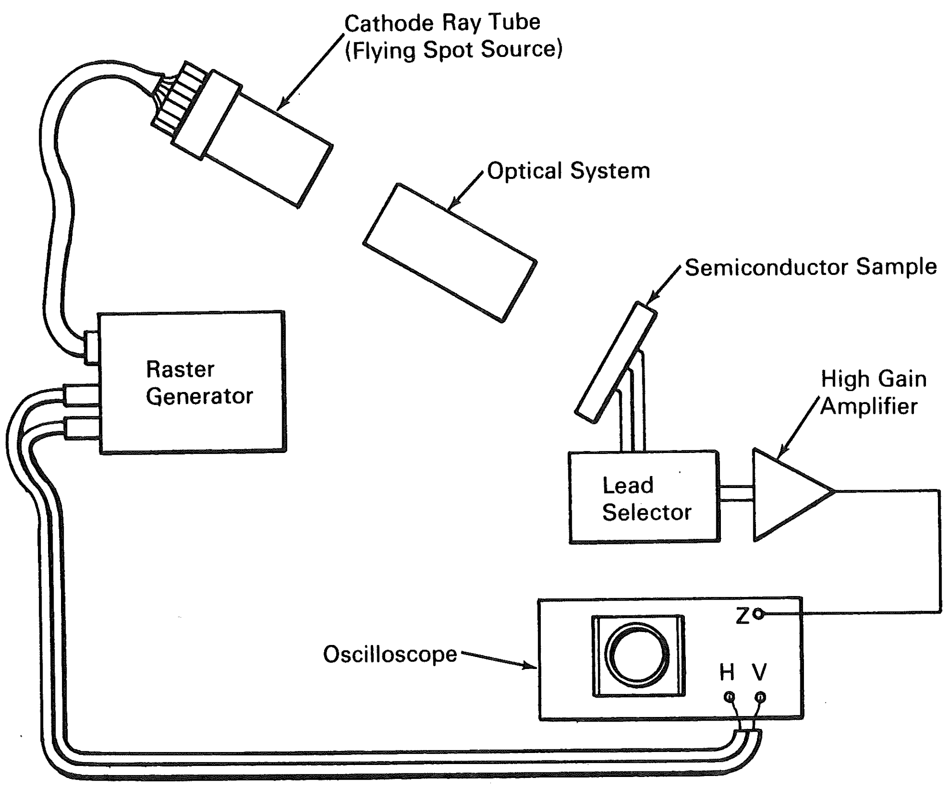
Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to the V. K. C. Aerojet-General Corporation, Azusa, California.

Source: J. S. Shenkman
of V.K.C. Aerojet-General Corporation
under contract to
Western Operations Office
(WOO-235)

May 1966 Brief 66-10200

NASA TECH BRIEF

Apparatus Presents Visual Display of Semiconductor Surface Characteristics



The problem:

To devise an apparatus that will provide a representation of the physicochemical condition of the surface layers of a semiconductor.

The solution:

An apparatus based on the principle that the surface layers of a semiconductor will conduct an electric current when exposed to a beam of light.

How it's done:

The apparatus consists of a raster generator that produces a rectangular scanning pattern similar to that of a commercial television set, an optical system, a lead selector that provides an electrical path between any two electrodes positioned on the surface of the semiconductor, a high-gain amplifier, and an oscilloscope. The horizontal and vertical sweep voltages

(continued overleaf)

of the oscilloscope are synchronized with those of the raster generator, and the output voltage from the amplifier is fed to the Z-axis for intensity modulation of the oscilloscope.

As the light beam from the optical system scans the surface of the semiconductor, the instantaneous current between pairs of selected electrodes connected to the semiconductor will vary in accordance with the characteristics of the surface between the electrodes. The variations in the light intensities of the pattern on the oscilloscope correspond to the current variations and permit analysis of the surface layer characteristics of the semiconductor sample with respect to the inversion layer, diffusion voids and excesses, crystal imperfections, and masking problems.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B66-10200

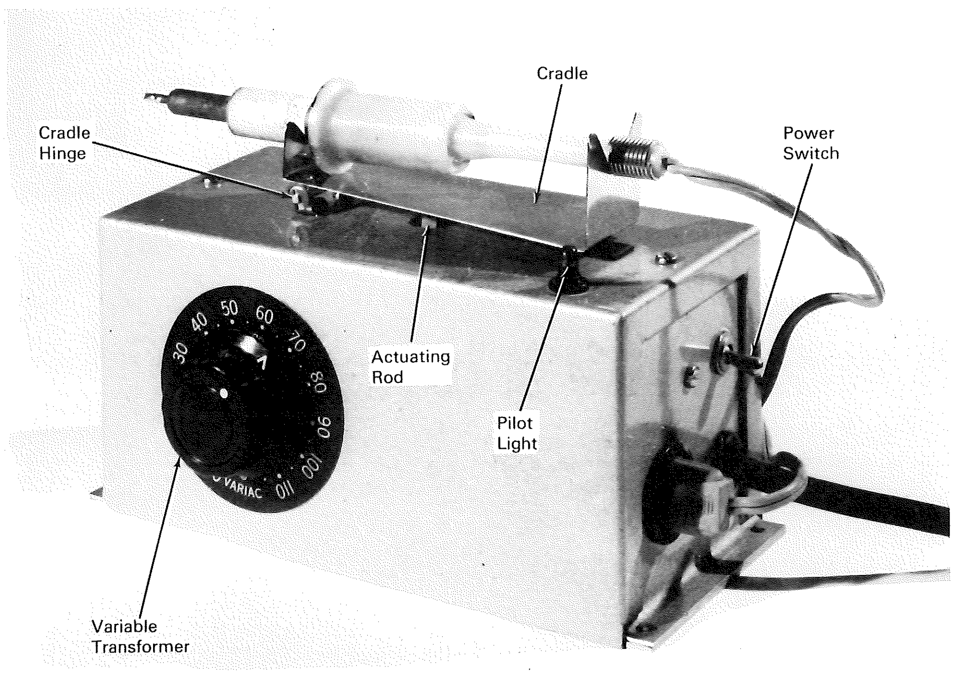
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Roy A. Summers
(JPL-665)

NASA TECH BRIEF

Soldering Iron Temperature Is Automatically Reduced



The problem:

To design an automatic, inexpensive, and reliable means of maintaining a soldering iron at less than peak temperature when not in use. The iron must be returned to operating temperature without undue delay.

The solution:

A hinged cradle-microswitch arrangement that introduces a voltage reducing element into the soldering iron power circuit when the iron is placed on the cradle.

How it's done:

The soldering iron cradle is hinged at one end, free at the other, and its center is poised on the actuating rod of a single-pole, double-throw microswitch. The cradle weight distribution is such that the microswitch spring tension supports the empty cradle with the switch connecting the soldering iron to the power source directly. When the soldering iron is placed on the cradle, the added weight overcomes the microswitch spring tension and moves the switch contact to connect the soldering iron to the power source

(continued overleaf)

through a variable transformer that can be set to reduce power to the iron by any desired amount. When the soldering iron is lifted from the cradle, spring tension moves the microswitch contact to again connect the iron to the power source directly.

Notes:

1. A less expensive variation would use a series of fixed resistors and a selector switch in place of the variable transformer.
2. Recovery time from standby temperature to operating temperature is on the order of 15 to 30 seconds.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California, 94035
   Reference: B66-10203

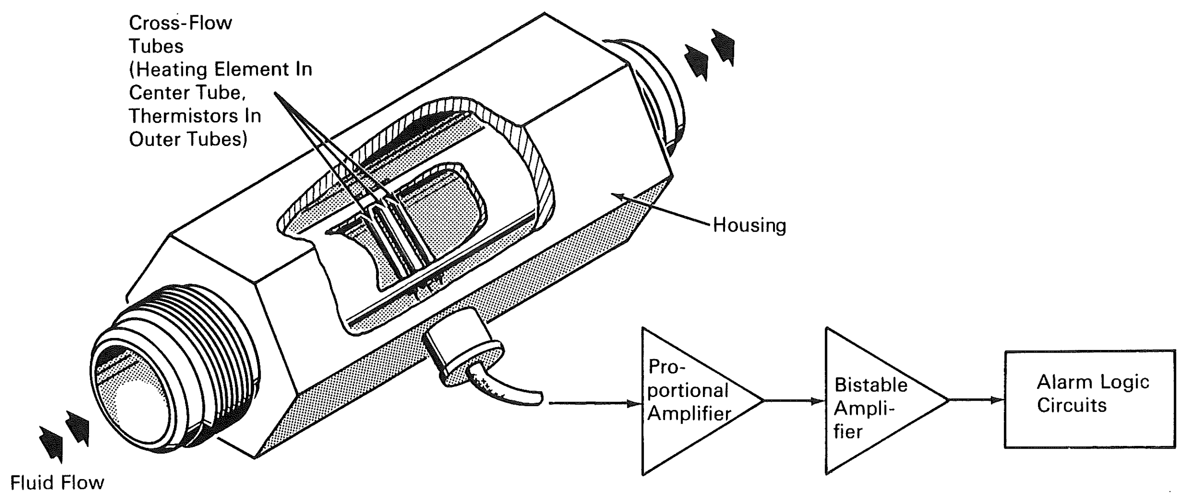
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: John Y. Lum
(ARC-57)

NASA TECH BRIEF

Wide-Range Instrument Monitors Flow Rates of Chemically Active Fluids



The problem:

To devise an in-line transducer system that will measure low and high flow rates of propellant fluids consisting of strong oxidants (e.g., nitrogen tetroxide) or thermally unstable fuels (e.g., hydrazine). The low-flow transducer is to be operated intermittently whenever it is desired to check for low-flow leakage (10 cc per hour to 10,000 cc per hour). The high-flow transducer, to be used for continuous operation (except during low-flow leakage checks), is required to provide flow-rate indications whenever the propellant flow rate ranges from 1000 cc per hour to 2×10^6 cc per hour. Conventional electrothermal flowmeters do not meet requirements with respect to allowable electrical power consumption and propellant compatibility.

The solution:

A system incorporating two specially designed electrothermal transducers, one operating as a low-flow transducer and the other as a high-flow transducer. Each consists of separate heater and temperature-sensing elements sealed in small stainless-steel tubes that are positioned in a cross-flow configuration and welded to the walls of a stainless-steel tube, which is then welded into a stainless-steel outer housing.

How it's done:

Two thermistors which serve as temperature sensors in the low-flow transducer illustrated are arranged in a thermally symmetrical configuration with respect to the heater element to provide differential temperature response to all effects except those due to flow. The high-flow, cross-tube transducer is identical in principle to the standard heated-wall electrothermal flowmeter. The primary difference is that the new high-flow configuration measures the heat transfer coefficient at the leading edge of a small cylinder, while the heated-wall meter measures the heat transfer coefficient at the wall of the main flow tube. The

(continued overleaf)

total heated area exposed in the high-flow cross-tube transducer is greatly reduced compared to the heated-wall system and provides for much greater sensitivity and correspondingly lower input power.

The thermistor sensing elements used in both transducers are sealed in glass and the units are cast into thermally conductive epoxy resin plugs which snugly fit the bore of the cross-flow tubes. The potted thermistors are then pressed into place and retained with a small spot of epoxy resin. The heater resistors are positioned in the cross tubes and bonded at both ends with epoxy resin. All electrical leads are then resistance-welded to nickel ribbons which are welded to an electrical connector having a stainless-steel body and gold-plated stainless-steel pins. The pins are individually insulated from the connector body by silicoceramic inserts.

Either transducer can be switched into a bridge circuit that feeds a proportional amplifier. A bistable amplifier and logic circuitry are arranged to produce an alarm signal when the fluid leakage or flow rate exceeds preset limits.

Notes:

1. Less than 2 watts at 28 volts are consumed by the instrument in either range.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77058
   Reference: B66-10205

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Spacelabs, Inc.,
under contract to
Manned Spacecraft Center
(MSC-186)

NASA TECH BRIEF

Ultrasonic Recording Scanner Used for Nondestructive Weld Inspection

The problem:

To design a lightweight, portable instrument for nondestructive inspection of welds.

The solution:

An ultrasonic recording scanner.

How it's done:

The scanner employs two point-beam ultrasonic transducers mounted in a V configuration, so that the ultrasonic beams intersect at a common point on the test surface. One transducer transmits the ultrasonic signal and the other receives the ultrasonic signal reflected from the test surface. The chart recorder is a simple independently driven paper roller system.

In operation, the transducers are focused over the weld area. While in this position, the transducer system is oscillated back and forth across the weld area. The ultrasonic signals transmitted and received by the transducers are relayed through a commercial power pack. So long as the weld area presents a uniform field to the transmitted ultrasonic wave, the stylus remains in contact with the chart paper and records a tracing of the ultrasonic signals picked up by the receiving transducer. The moment a change appears in the weld area, the ultrasonic signal relayed through the power pack energizes the solenoid, which causes the stylus to retract from the paper, leaving a blank space on the chart. As soon as a uniform area is again detected, the solenoid releases the stylus to make contact with the recording paper. In this manner, the entire scanned weld area is represented by a series of tracings and blank spots on the chart. The resultant chart provides a simple, direct-reading record of the weld quality, without requiring further processing or transcription of the data.

Notes:

1. The recording scanner is adaptable to continuous operation in one direction while maintaining oscillatory motion at 90° to this direction. The scanning speed and oscillation frequency are independently adjustable. Each recording can be code-numbered by remote control to identify the weld location.
2. A related innovation is described in NASA Tech Brief B66-10178, May 1966. Inquiries may also be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10220

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: The Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-284)

Category 01

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Multicolor Stroboscope Pinpoints Resonances in Vibrating Components

The problem:

To devise a stroboscopic system that will rapidly scan a vibrating multicomponent assembly and provide a visual indication of resonant components. Conventional stroboscopic systems employ a light flashing at a frequency of 1 to 5 cps slower or faster than the vibration frequency. The apparent rate of displacement of the vibrating component indicated by these systems is equal to the difference between the flash frequency and the vibration frequency. Each component must be observed for at least 0.5 second to estimate its displacement amplitude relative to that of adjacent components. If the light is pulsed to flash when the driving force of the vibration exciter crosses zero, those components at resonance will be illuminated at the positive and negative peak displacements (amplitudes). For small displacement amplitudes, this arrangement shows only a slight increase in the component dimensions parallel to the direction of vibration.

The solution:

A visual detection system, using three different colored lights that are pulsed at the same flash frequency but at different phases.

How it's done:

The three lights are arranged to flash at the peak positive and negative forces as well as the zero-force crossing of the vibration exciter. The relative position of the vibrating component at the time of flashing is determined by the phase shift between the force and displacement that occur at resonance. Below resonance, displacement from the mean position is indicated by the lights which flash at the peak of force; while at resonance, the light which flashes at the zero-force crossing illuminates the component at its point of displacement from the mean position. For displacement amplitudes above a certain minimum, the conditions below, at, and above resonance are illuminated. When the component is at mechanical resonance, it is surrounded by a halo which corresponds in color to that of the light which flashes when the force is zero. The lights which flash at the peak of the force provide a reference position, and the colors allow rapid visual scanning of a multicomponent assembly for pinpointing of resonant components. These resonant components are identified by halos of the zero-force color.

In tests using only two colors of light, the signal used to drive the lamps was obtained from a three-phase tachometer attached to the vibration exciter alternator. One light was controlled directly from this signal, and the other from the rotor voltage of a synchronous motor. In this way the phase angle between the firing of the two lamps could be varied by simply adjusting the position of the rotor in the synchronous motor.

Notes:

1. While the displacement resolution (0.01-inch peak-to-peak amplitude) of this system is no better than that of a standard stroboscope, it will facilitate the isolation of resonant components in a complex assembly.
2. This system may be adaptable to a number of applications: in environmental component testing, either for relative evaluation or warning of vibration extremes; in short-range communication of limited security, based on modulating the phase shift of two colors; and in advertising or demonstrations where the novelty of displaying two

(continued overleaf)

objects or causing an object to suddenly shift its apparent position could be used to attract attention.

Patent status:

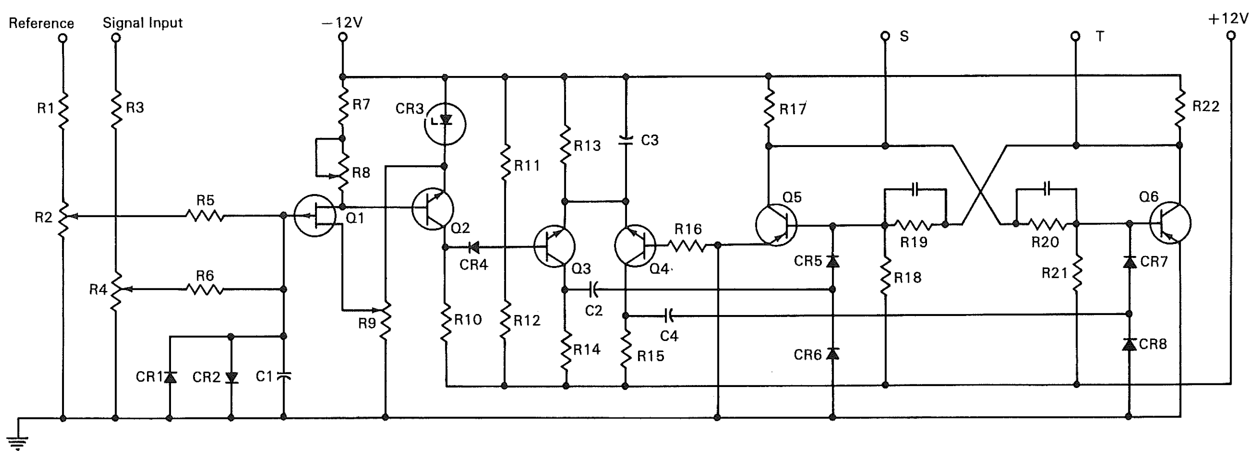
Title to this invention, covered by U.S. Patent No. 2909059, has been retained by the California Institute Research Foundation, Pasadena, California.

Source: Eric G. Laue
California Institute Research Foundation
under contract to
the U.S. Army
(JPL-0033)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

FET Comparator Detects Analog Signal Levels Without Loading Analog Device



The problem:

To design a voltage comparator circuit capable of detecting discrete analog computer output levels without excessively loading the output amplifier of the analog computer. The circuit must provide a digital output for analog voltages above or below a predetermined level. The cost and complexity of the circuitry must be lower than those of a conventional analog-to-digital converter.

The solution:

An FET (field effect transistor) common source amplifier to provide high input impedance and temperature stability, coupled by a differential amplifier to a bistable transistor flip-flop.

How it's done:

The circuit consists of four subsections: an input overload protection circuit (CR1 and CR2, with coupling isolation resistors, R1–R6); a high input-impedance amplifier (Q1 and Q2); a differential amplifier (Q3 and Q4); and, a bistable flip-flop (Q5 and Q6). The circuit is initially aligned by grounding the gate of Q1 and adjusting R9 until the drain of Q1 approaches −6.6 volts. Q1 is pinched off and Q2 is at cutoff. In this condition, CR4 is back biased, permitting Q3 to conduct through bias resistors R11 and R12. The voltage drop across R13 back biases Q4 and its collector goes to +12 volts. This positive-going signal is coupled through C4 and CR7 and to the base of the flip-flop transistor Q6. Q6 is turned off and Q5 is turned on. Thus the T output goes to −12 volts and the S output goes to −0.6 volt. This is the "logic 1" output condition.

The gate of Q1 sees the voltage difference between an applied reference voltage and the analog signal input. If the difference between the reference and the analog voltages is positive, Q1 remains pinched off, and the output condition of "logic 1" exists. If the difference between these voltages is negative, the

(continued overleaf)

gate voltage causes Q1 to conduct, thus allowing Q2 to become forward biased. CR4 is forward biased, driving the base of Q3 negative. Thus Q3 is cut off and Q4 is forward biased. When Q3 is cut off, its collector goes to +12 volts. A positive-going signal is coupled through C2 to CR5 and to the base of flip-flop transistor Q5. Q5 is cut off, and Q6 is turned on. Thus, output S goes to −12 volts and output T goes to −0.6 volt. This is the "logic 0" output condition.

Notes:

1. This circuit could be used to provide the initial circuits for a relay-controlled logic scheme. A group of these comparator circuits could be connected to provide a pulse-code-modulated system supplying a digital output for sinewave inputs in a binary ratio, thus forming a counter.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama, 35812
   Reference: B66-10224

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: H. L. Wallace
of General Electric Company
under contract to
Marshall Space Flight Center
(M-FS-503)

NASA TECH BRIEF

Single-Crystal Semiconductor Films Grown on Foreign Substrates

The problem:

To grow single-crystal films of a semiconductor material on a substrate of foreign material, that is a material whose pertinent physical characteristics (lattice constant, thermal expansion coefficient, etc.) do not match those of the semiconductor material, thereby precluding epitaxial growth.

The solution:

Form an intermediate alloy between the foreign substrate (made of an appropriate metal) and the semiconductor material and grow the crystal film of this material on the alloy layer.

How it's done:

In one system, molybdenum sheet is used as the substrate and germanium as the semiconductor material for the film. The germanium is evaporated onto the molybdenum sheet and the temperature is increased, allowing the germanium to alloy with the surface layers of the molybdenum at a relatively high temperature, but below the melting point of the molybdenum. Vapor deposition of the germanium is repeated, but this time the alloying temperature is held somewhat lower than in the first step. In this manner, a molybdenum-germanium alloy of varying composition, having a melting point lying between the melting points of the molybdenum and germanium, is built up on the molybdenum substrate. Finally, a germanium layer, which will melt without appreciably reacting with the underlying alloy, is evaporated onto the alloy. The germanium layer can then be melted and recrystallized into single-crystal semiconductor films by any of a variety of methods, including seeding, normal solidification, and zone solidification. The recrystallized germanium film is in turn used as a substrate for the epitaxial growth of germanium or other semiconductors, such as gallium arsenide.

Notes:

1. In carrying out this process the melted semiconductor film must not ball up on the surface of the substrate and neither chemically react nor alloy with the intermediate alloy formed on the substrate.
2. The melting point of the base material must be higher than that of the film material.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California, 90406
   Reference: B66-10225

Patent status:

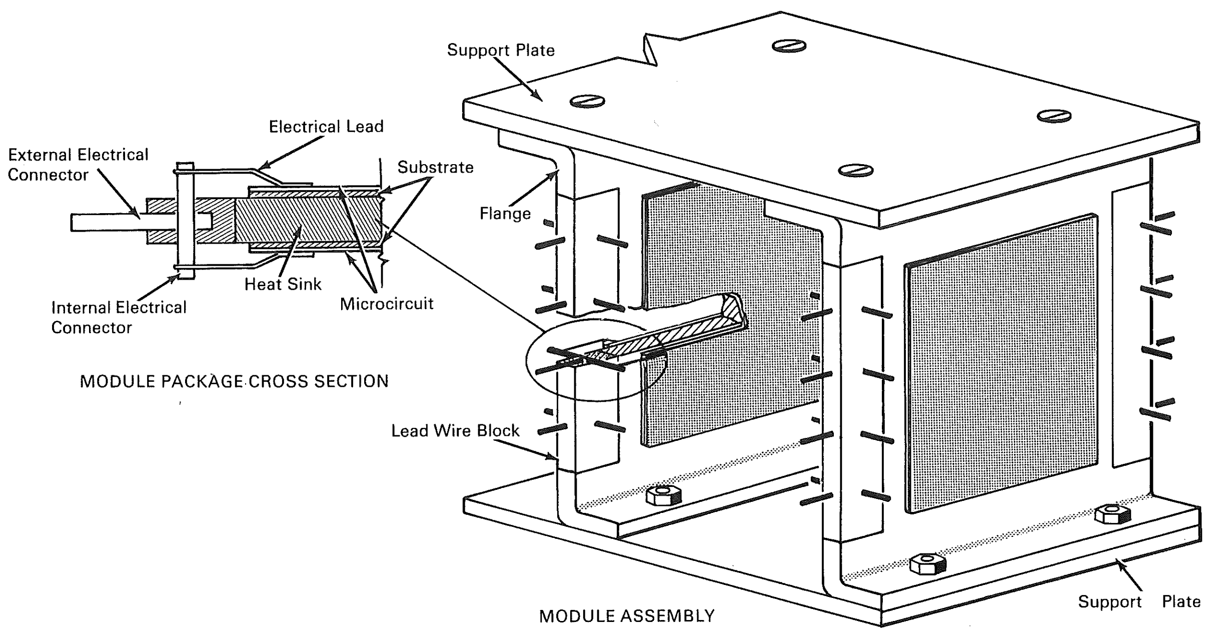
No patent action is contemplated by NASA.

Source: Paul Vohl
of Radio Corporation of America
under contract to
Western Operations Office
(WOO-076)

Category 01

NASA TECH BRIEF

Rugged Microelectronic Module Package Supports Circuitry on Heat Sink



The problem:

To devise a rugged, module package for thin film hybrid microcircuits. The module package must protect the circuitry from shock and vibration loads of up to 50 g, effectively dissipate internally generated heat, and simplify electrical connections between adjacent modules and to external circuits.

The solution:

A module package incorporating a rigid, thermally conductive support structure, which serves as a heat sink for the thin film hybrid microcircuits, and a lead wire block in which T-shaped electrical connectors are potted.

How it's done:

The heat sink structure of the module package, made of a metal having good thermal conductivity, is bent in opposite directions at its upper and lower ends to form flanges. Lead wire blocks of cast or molded epoxy resin are fastened to the other two opposite edges of the heat sink with an epoxy cement. The electrical connectors, welded to form a T-junction, are cemented into position in slots provided in the epoxy blocks. An electrically insulating substrate, such as glass, upon which the hybrid microcircuits are deposited, is cemented to each of the two faces of the heat sink. Electrical leads are welded between the ends

(continued overleaf)

of the internal electrical connectors and the circuits on opposite faces of the substrate. The cross-member connector of each T-junction is used to join the microcircuits to external circuitry. Any number of the module packages can be installed as an integral unit by bolting the heat sink flanges to a pair of parallel support plates.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
Reference: B66-10245

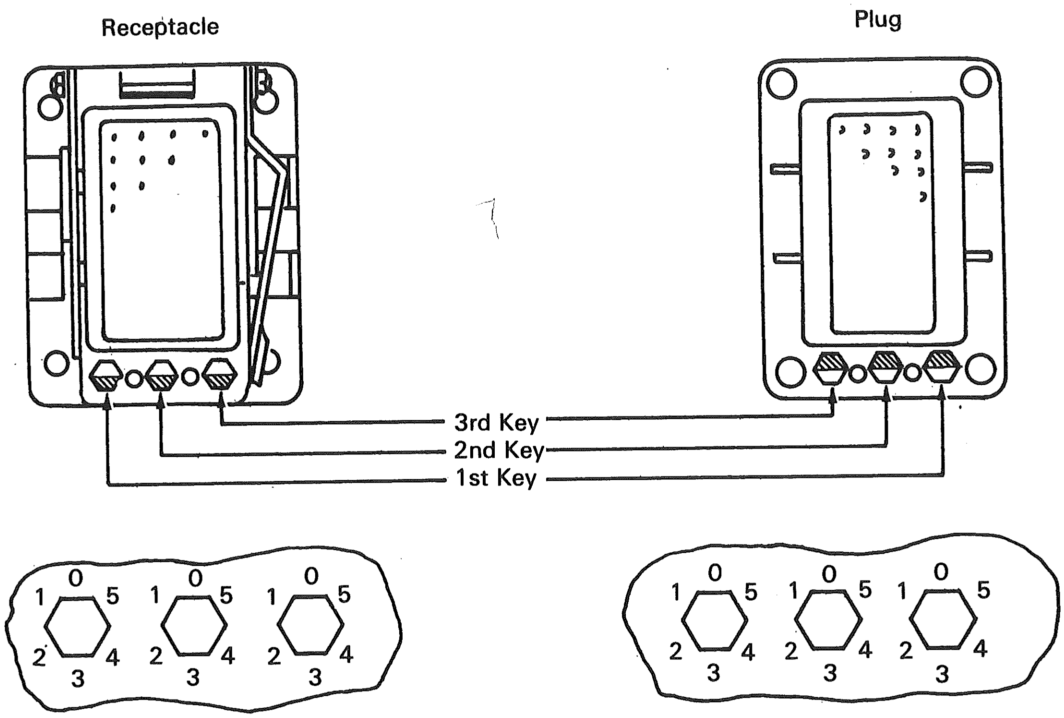
Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, non-exclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: A. L. Johnson
of Minneapolis-Honeywell Regulator Company
under contract to
Manned Spacecraft Center
(MSC-81A)

NASA TECH BRIEF

Polarizing Keys Prevent Mismatch of Connector Plugs and Receptacles



The problem:

In connector patching for instrumentation involving several thousand leads, the danger of mating the wrong plug and receptacle is always present. Improper mating can result in expensive delays, system malfunction, and even catastrophic failure.

The solution:

Connectors consisting of plugs and receptacles having keying provisions that permit the mating of a large number of connectors with no possibility of a mismatch. The back of the receptacle provides two sockets for patching to each individual plug lead.

How it's done:

Each receptacle and plug contains three polarizing keys that must mate in a complementary mode before the connector pins and sockets will engage. Each of the three keys in each unit may be oriented in any one of six selected positions. This provides a total of 216 different keying arrangements. Since each receptacle provides 128 patch sockets, the system will accommodate a total of 27,648 patch leads with no possibility of any plug-to-receptacle mismatch.

Notes:

1. This plug and receptacle system should be of use

(continued overleaf)

wherever complex test instrumentation must be frequently reconnected.

2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10251

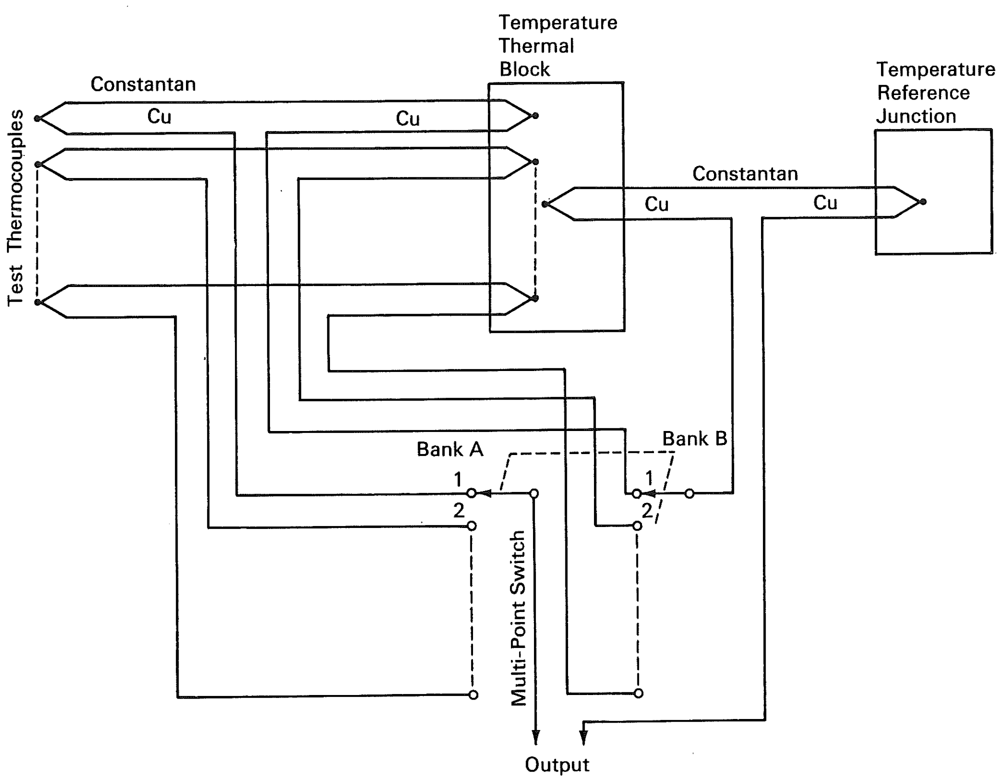
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: A. Chiapuzio
of North American Aviation
under contract to
Manned Spacecraft Center
(MSC-443)

NASA TECH BRIEF

Multiple Temperatures Sampled Using Only One Reference Junction



The problem:

To reduce the number of reference thermocouples, cabling, and cost of a multitemperature sampling system where the reference thermocouples are a distance from the test thermocouples. Previously, each test thermocouple required a separate reference junction, adding to the cost and complexity of the system.

The solution:

An intermediate thermal junction block is placed between the test thermocouples and the reference junction permitting switching between a single reference and the test thermocouples.

How it's done:

The constantan lead of each test thermocouple is connected to the constantan wire of an electrically

(continued overleaf)

insulated thermocouple in the intermediate thermal junction block. The copper leads of this pair of thermocouples are brought to banks A and B of the switch. The reference thermocouple is connected to a thermocouple on the intermediate thermal block and brought into the switch in a similar manner. In any one position of the switch, the test thermocouple, the reference thermocouple, and their corresponding thermocouples on the intermediate thermal junction block are connected in series. Since the intermediate thermocouples from the reference and test junctions are at the same temperature and are series connected, thereby producing equal but opposite voltages, their influence on the system cancels. The output then is the voltage difference between each test thermocouple and the reference thermocouple.

Notes:

1. The particular temperature of the intermediate thermal block is of no consequence so long as it is uniform and does not exceed the limitations of exposed materials.
2. Since all leads brought to the switch are copper, no additional error is introduced by the switching system.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10260

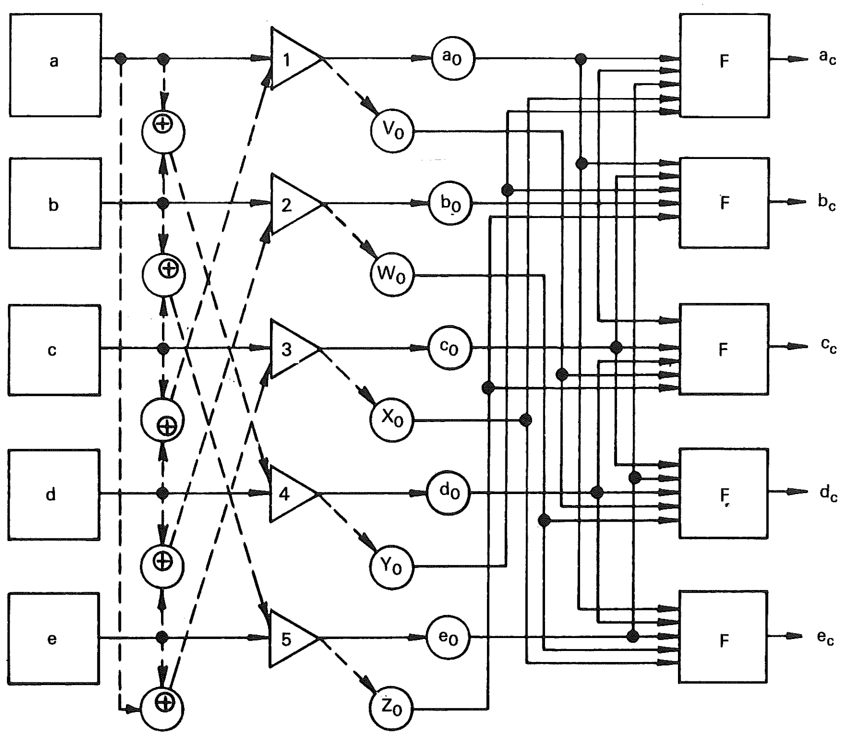
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: George W. Cope
(GSFC-485)

NASA TECH BRIEF

Simplified Circuit Corrects Faults in Parallel Binary Information Channels



The problem:

To prevent the appearance of erroneous output signals from the possible failure of any single channel element interconnected in parallel binary information channels, various redundant circuits have been used. Although these redundant circuits accomplish the desired result, they are unduly complex and costly.

The solution:

A circuit that corrects for any single temporary or permanent fault in one set of channels which serve several independent data sources, without using any redundant channels.

How it's done:

The system, illustrated for five independent binary signal sources, a, b, c, d, and e, includes signal channels through amplifiers 1, 2, 3, 4, and 5; temporary storage elements a_0, b_0, c_0, d_0, e_0, V_0, W_0, X_0, Y_0, and Z_0; and logic elements, F, for error corrections.

The signals a, b, c, d, and e are used for two transmissions. On the first transmission the signals are sent

through amplifiers 1, 2, 3, 4, and 5 respectively, using the paths indicated by the solid lines entering and leaving the amplifiers, and the observed values are temporarily stored in elements a_0, b_0, c_0, d_0, and e_0. On the second transmission, pair-wise parity functions produced by exclusive *OR* logic gates are transmitted through the amplifiers, using the paths indicated by dashed lines. Thus the functions $a \oplus b$, $b \oplus c$, $c \oplus d$, $d \oplus e$, and $e \oplus a$ are transmitted through amplifiers 4, 5, 1, 2, and 3, respectively, and the observed values are temporarily stored in elements Y_0, Z_0, V_0, W_0, and X_0, respectively.

The signals a_c, b_c, c_c, d_c, and e_c are generated by the combinational logic-elements, F, according to the following rules:

$$a_c = \text{Majority}\ (a_0, Y_0 \oplus b_0, X_0 \oplus e_0)$$
$$b_c = \text{Majority}\ (b_0, Y_0 \oplus a_0, Z_0 \oplus c_0)$$
$$c_c = \text{Majority}\ (c_0, V_0 \oplus d_0, Z_0 \oplus b_0)$$
$$d_c = \text{Majority}\ (d_0, V_0 \oplus c_0, W_0 \oplus e_0)$$
$$e_c = \text{Majority}\ (e_0, X_0 \oplus a_0, W_0 \oplus d_0)$$

Each function is the majority of three versions of the same original variable. For example, since Y is obtained by transmitting $a \oplus b$, if there is no error, $Y_0 \oplus b_0 = (a \oplus b) \oplus b = a$; similarly, $X_0 \oplus e_0$ should be $(a \oplus e) \oplus e = a$. Since all the variables in the function are obtained from different amplifiers, an error in one amplifier can change only one value. Since at least two of the three terms in the majority function will be correct, the function still produces the true value of the original variable.

Note:

A related innovation is described in NASA Tech Brief B65-10025, February 1965. Inquiries may also be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10261

Patent status:

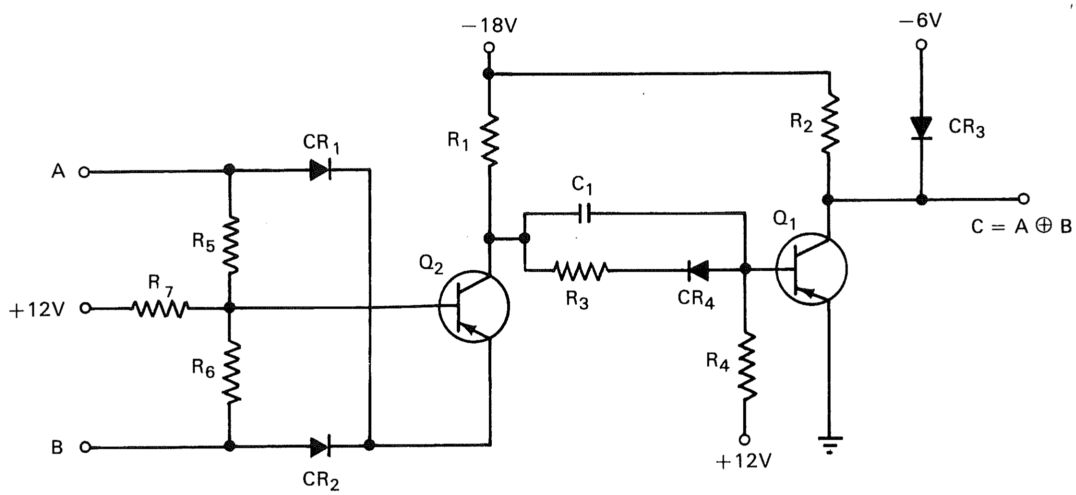
No patent action is contemplated by NASA.

Source: Jacob Goldberg
of Stanford Research Institute
under contract to
Jet Propulsion Laboratory
(JPL-SC-090)

June 1966 Brief 66-10272

NASA TECH BRIEF

Exclusive-Or Logic Circuit Has Useful Properties



The problem:

A *Exclusive-Or* B, written A$\oplus$B, is commonly implemented with conventional (*And/Or, Nor, Nand,* etc.) logic connectives. Such implementation, however, requires an excessively large number of connectives (normally five) to perform the one logic operation. Desired, therefore, is a single, simple *Exclusive-Or* connective; its proper use would substantially reduce total system hardware and number of interconnections between logic modules. The reduction is demonstrated in the familiar full adder where the sum bit S is commonly implemented with five multi-input conventional connectives; only two (two-input) *Exclusive-Or* connectives are required, however, since S can be expressed as $S = A \oplus B \oplus C$, where A, B, and C represent the augend, addend, and carry, respectively. Furthermore, the common implementation requires both assertion and negation inputs.

The solution:

The essential feature of the circuit is contained in the left portion of the figure, where CR_1, CR_2, R_5, R_6, and Q_2 are interconnected to perform the necessary switching for the *Exclusive-Or* operation. The right portion merely amplifies, restores, and inverts the signal.

How it's done:

Assume that the nominal voltages of −6 and 0 represent true and false, respectively. By examining the four input conditions, it is seen that CR_1, CR_2, R_5, R_6, and Q_2's base and emitter are interconnected so that Q_2 conducts *iff* (if and only if) either of the two inputs is true and the other is false (i.e., *iff* $A \oplus B$). R_7 optimizes the input noise rejection by establishing the proper turn-on threshold of Q_2.

The relative values of R_1, R_3, and R_4 are such as to give maximum drive capability (four unit loads or

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9.6 ma) without exceeding one unit load (2.4 ma) at the input. In addition, the relative values of R_3 and R_4 are such that they maintain Q_2 in the off condition even in the presence of 2 volts noise.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia 23365
Reference: B66-10272

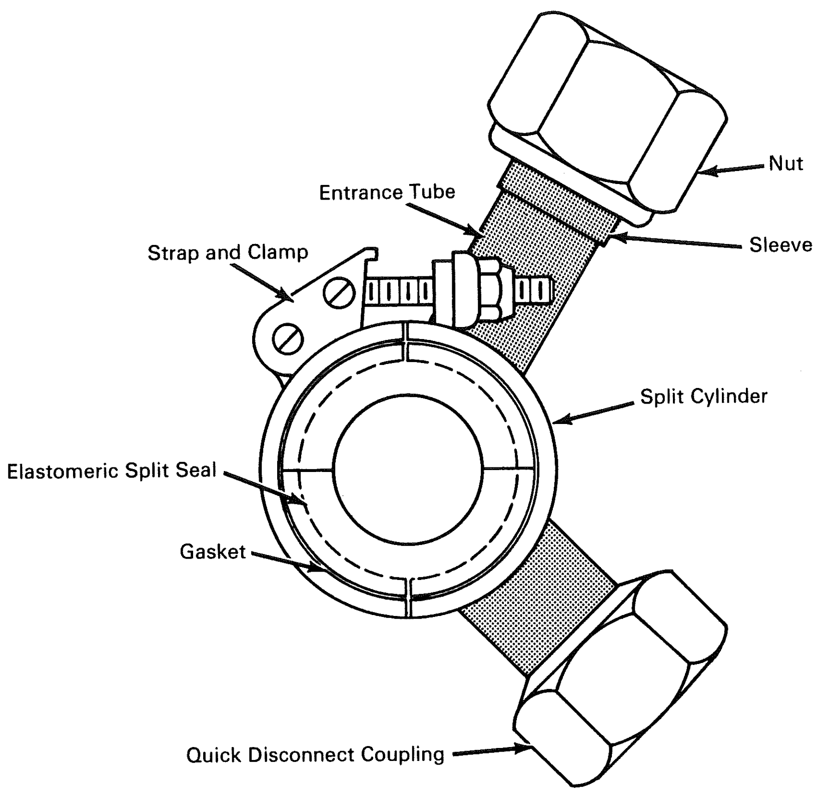
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: William G. Batte
(Langley-214)

NASA TECH BRIEF

Vacuum Test Fixture Improves Leakage Rate Measurements



The problem:

To improve leakage rate measurements of individual connections, brazed joints, and entrance ports used in closed fluid flow line systems. Present probe and bell jar methods are capable of leakage rate measurements on the order of 10^{-5} cc/s; a capability of 10^{-6} cc/s is desirable.

The solution:

A vacuum test fixture that is essentially a cylindrical chamber, consisting of two matching halves.

How it's done:

The test fixture is open ended permitting it to be fitted over various sized pipe or flow lines. A strap and clamp arrangement, near both ends of the fixture, holds the halves of the fixture together until the chamber is sufficiently evacuated and the atmospheric pressure provides the needed holding force. The fixture is closed at both ends by elastomeric split seals, which are made in various sizes to accommodate variable pipe and flow line diameters.

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The entrance tube provides a port for evacuating the chamber and permits the leakage rate measurement to be made. Upon evacuation, the elastomeric split seals are forced inward, effectively sealing the chamber.

The coupling quick disconnect port is normally closed during the evacuation and leakage rate measurement. At the end of the test, the coupling quick disconnect port is opened to reduce the vacuum quickly and to enable the test fixture to be removed.

Notes:

1. The quick disconnect port and the entrance tube are both fastened to the same half cylinder by induction brazing.
2. The strap and clamp are not required because the two halves of the test fixture can be held together by hand until the chamber has been sufficiently evacuated, permitting the atmospheric pressure to hold the two halves of the chamber together.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10286

Patent status:

No patent action is contemplated by NASA.

Source: Harry Marx and Henry Maier
of Grumman Aircraft Corp.
under contract to
Manned Spacecraft Center
(MSC-271)

June 1966

Brief 66-10264

NASA TECH BRIEF

Binary Sequence Detector Uses Minimum Number of Decision Elements

The problem:

To provide a detector of an n bit binary sequence code within a serial binary data stream, using a minimum number of elements in the detector. To date there is no known algorithm for assigning states or combinations of states to the memory elements of a code sequence detector that yields combinatorial logic of minimum complexity.

The solution:

A procedure that, given the linear recursion relationship employed by the sequence generator, will employ the same ordering of states for the sequence detector as that of the sequence generator.

How it's done:

The selection of the initial state assignment is performed by assigning p initial states to the sequence detector, where p is the smallest integer greater than or equal to the logarithm (base 2) of n. Then the Boolean equations are written and minimized for each of the p initial state cases. Of the p cases, the case that results in the combinatorial logic of minimum complexity is implemented for the sequence detector. The resulting sequence detector consists of p memory elements interconnected by combinatorial logic employing decision elements.

The sequence detector must assume at least n states to detect an n bit sequence. The detector will require a sufficient number of memory elements for each of the n states. The minimum number of two-state or binary memory elements required is $p = [\log_2 n]$.

The successive combination of states the sequence generator (shift register) assumes provides an ordering of states for the detector that leads to a relatively small number of logic elements for the detector. Therefore, the successive states of the detector are made to correspond to the successive states of the generator shift register.

A state table is constructed that contains, for each of the n states corresponding to the incoming serial code stream, the next state that the detector should assume. For the valid code sequence the detector should successively assume states 1, 2, . . . n, and on the nth input bit should produce a signal signifying that the valid code sequence has occurred. Also, at this point the detector should revert to the initial state. For nonvalid code sequences the detector should successively assume states for as long as the nonvalid code stream matches the valid code sequence. At the first code bit that does not match the valid code, the detector should revert to an earlier state.

For instance, assume the detector is designed to have 31 states for detecting a 31 bit code sequence and the detector is in state 18, having received 17 bits that corresponded bit-by-bit with the first 17 bits of the valid code. Should the 18th input bit not correspond to the 18th bit of the valid sequence, the detector would not progress to the 19th state but would instead revert to an earlier state. The state to which the detector reverts would take into consideration the code prefix possibility. For example, if the detector has reached its 18th state before encountering an incoming bit that does not match the valid code, the state to which the detector would revert is not necessarily the first state. The next state is a function of the match of the most recently received bits to the beginning of the valid code. Assuming the most recently received 4 bits match the first 4 bits of the valid code, the detector would revert to state 5 rather than state 1.

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For each of the p candidate initial states, the set of combinatorial logic equations is written. Their implementation would cause the detector state sequence to correspond to the generator state sequence upon receipt of the valid code sequence. Following minimization of the sets of equations by standard techniques, the set that requires the minimum number of logic elements is selected for implementation. The design procedure avoids extensive or exhaustive evaluation of the n! possible state sequences which could be implemented in the detector.

As an example of the logic element requirement for a 31 bit code sequence detector, the method outlined above results in logic consisting of only five memory elements in the form of RS flip–flops and 17 NAND gates. This compares quite favorably with an alternative straightforward implementation of a 31 stage shift register as a code sequence detector, where the logic required totals 31 memory elements (flip–flops) and one 31 input decision element (and circuit).

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B66-10264

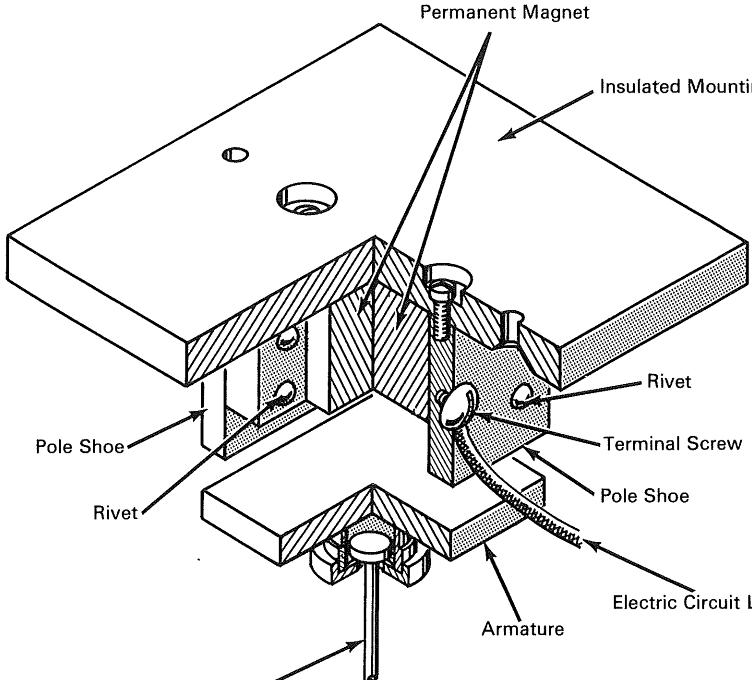
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Marvin Perlman
(JPL-673)

NASA TECH BRIEF

Magnetically Operated Limit Switch Has Improved Reliability, Minimizes Arcing



The problem:

To design a reliable, low travel, snap action limit switch that operates with negligible arcing. Most conventional low travel limit switches use a current-carrying spring and a plunger which requires considerable actuating and holding forces. These switches arc excessively on make and break, and tend to be unreliable because they consist of a relatively large number of parts.

The solution:

A limit switch that employs an electrically nonconductive permanent magnet consisting of a ferrimagnetic ceramic and ferromagnetic pole shoes that form a magnetic and electrically conductive circuit with a ferrous metal armature.

How it's done:

The electrically conductive pole shoes are mounted with rivets on opposite pole faces of the ferrimagnetic, electrically nonconductive ceramic. Terminal screws connect an external electrical monitoring circuit to the pole shoes. The electrically conductive armature is arranged to face the ends of the pole shoes. A movement differential required for snap action is provided by the space between the armature and the

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actuating plunger, which is connected to the device to be monitored.

In operation, the armature will be rapidly attracted to the pole shoes somewhat ahead of the plunger, thereby closing the external electrical circuit. The electrical circuit is broken rapidly, shortly after the start of the downward movement of the plunger. These rapid make and break actions suppress arcing, thereby minimizing contact erosion. Because the current is interrupted within a magnetic field, arcs will also be extinguished by the well-known blowout action.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas, 77058
Reference: B66-10270

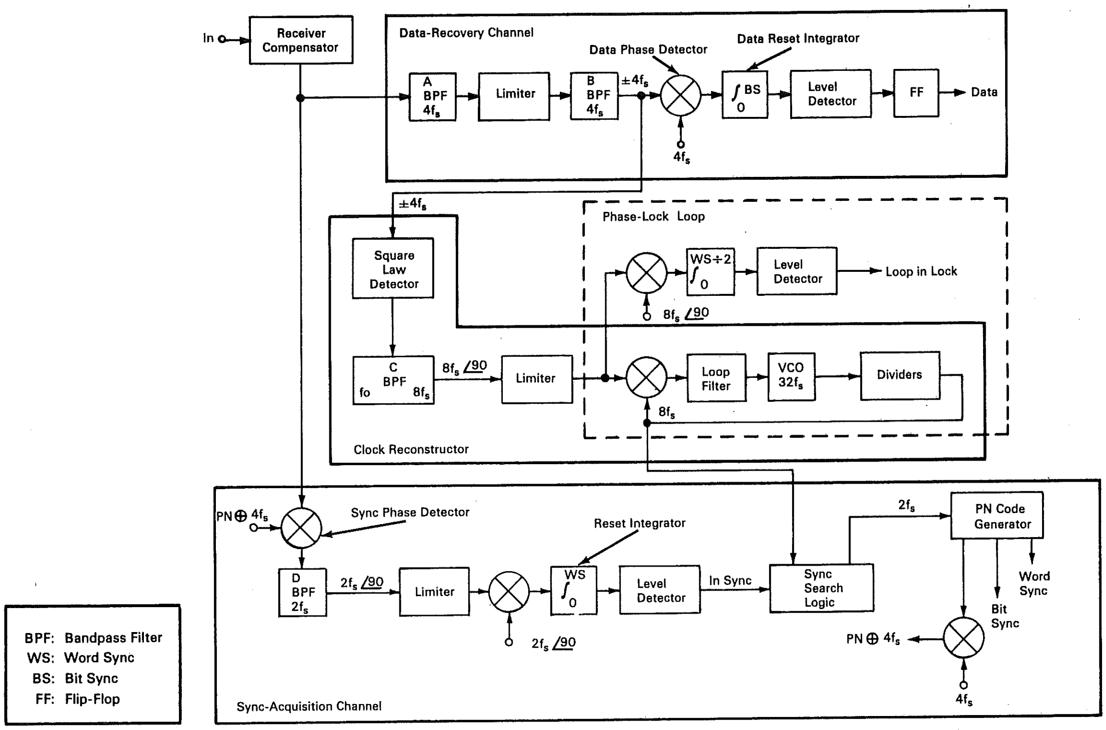
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Rudolf Steiner
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-422)

NASA TECH BRIEF

PN Acquisition Demodulator Achieves Automatic Synchronization of a Telemetry Channel



The problem:

To provide an automatic means for obtaining initial word and bit synchronization in a pulse-code-modulated/phase-shift-keyed digital communications system. One solution has been to continuously transmit synchronism information over the channel, in parallel with the data information in the form of a pseudorandom (pseudonoise, PN) sequence with a two-level autocorrelation function. The most difficult problem in such a system is the detection of the maximum in the cross correlation between the noisy and the replica codes during initial synchronization. Present methods often require extensive manual operations which are generally time consuming and inefficient.

The solution:

A data demodulator for automatic sync acquisition. Basically, the system generates a clock frequency harmonically related to the PN code generator clock but of ambiguous phase, and then solves the ambiguity by digitally retarding or advancing the ambiguous clock phase until the maximum in the cross-correlation is detected, The ambiguous clock is easily generated

(continued overleaf)

in the two-subcarrier (double-channel) system by utilizing a quadratic detector to remove the data modulation from the 180° phase-shift-keyed subcarrier.

How it's done:

The composite input signal to the demodulator is made up of a synchronization PN code multiplying a $2f_s$ subcarrier which is linearly added to data multiplying a $4f_s$ subcarrier. The PN code is clocked at $2f_s$. This signal is described in the equation:

$$\text{Sig In} = \text{PN} \oplus 2f_s + 4f_s \oplus \text{Data}.$$

The input signal is applied to bandpass filter (BPF) A and a synchronization phase detector. Bandpass filter A passes only the $4f_s$ subcarrier and data which are amplified, limited, and refiltered by a limiter amplifier and bandpass filter B. The output of bandpass filter B is applied to a data phase detector and a square law detector. The output of the data phase detector is applied to the data reset integrator which is reset by the bit-sync signal obtained by decoding a specific state of the local PN generator. The polarity at the end of each integration is detected and utilized to steer a flip-flop, the output of which is data. The square law detector eliminates data from the signal at its input. The output of the square law detector passes through bandpass filter C which is centered at $8f_s$. The resulting $8f_s$ sine wave is limited and applied to a phase-lock loop. The voltage controlled oscillator (VCO) in this loop serves as the clock source for all digital signals generated in the demodulator. Included in these digital signals are PN, $\text{PN} \oplus 4f_s$, $8f_s$, $8f_s\underline{/90^\circ}$, $4f_s$, $2f_s$, $2f_s\underline{/90^\circ}$ and the word- and bit-sync signals.

In the synchronization phase detector, the incoming signal is multiplied by local $\text{PN} \oplus 4f_s$ which results in $2f_s\underline{/90^\circ}$ (when the incoming and local PN codes are aligned). This $2f_s\underline{/90^\circ}$ is filtered, limited, and multiplied by local $2f_s\underline{/90^\circ}$. The output of this last multiplier is applied to a reset integrator which is reset at word-sync intervals. This integrator is biased so that a positive output exists only at the maximum in the cross-correlation between the received local and the PN codes. The output of the reset integrator is applied to a level detector circuit, which in turn steers a flip-flop which yields an in-sync signal when the integrator output is positive.

Notes:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B66-10271

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Lucien Couvillon
(JPL-612)

NASA TECH BRIEF

Braze Alloys Used as Temperature Indicators

The problem:

To devise a method of measuring temperatures over the range of 175° to 2100° F on metal surfaces where it is not feasible to employ conventional temperature detectors such as thermocouples and thermistors.

The solution:

Apply patches of braze alloys having known fusion points to portions of the surface where temperature indications are required.

How it's done:

Several braze alloys having fusion points lying on either side of the estimated temperature to be measured are selected. Small patches of these alloys (approximately 0.25-inch diameter × 0.002-inch thick) are fused onto the surface of the base metal before it is exposed to operating temperature, and scribe marks are made on the solidified alloy deposits. When the surface is heated, the patches that fuse at temperatures above the operating temperature of the base metal will remain unaffected. The scribe marks on the patches that fuse at or below the operating temperature of the base metal will disappear. A detailed inspection of the alloy patches after the base metal has been cooled will provide an indication of the temperature reached by the base metal.

Notes:

1. By proper selection of braze alloys or solders, it should be possible to measure metal surface temperature with an accuracy of 30° to 50° F.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C., 20545
   Reference: B66-10274

Patent status:

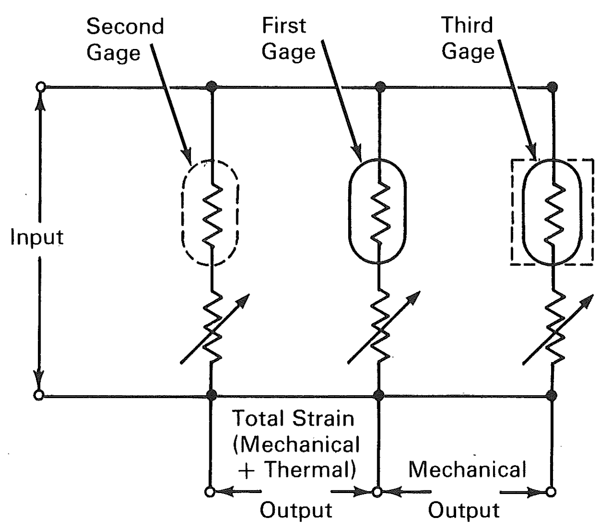
No patent action is contemplated by NASA.

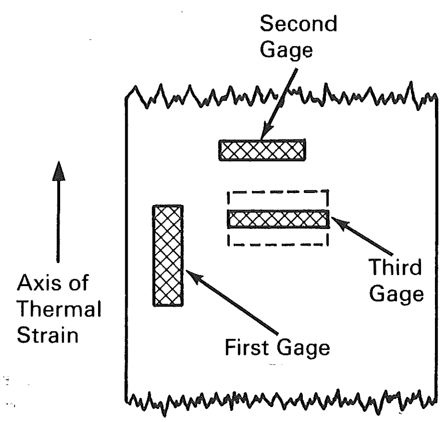
Source: L. A. Shurley and R. E. Rice
of Aerojet-General Corporation
under contract to
Space Nuclear Propulsion Office
(NU-0063)

Category 01

NASA TECH BRIEF

Strain Gage Network Distinguishes Between Thermal and Mechanical Deformations





The problem:

To measure the thermal coefficient of linear expansion of composite metal structures. Sampling methods are reliable only to the extent of the sample size and optical methods are prohibitively expensive.

The solution:

A strain gage network consisting of a test gage and two dummy gages arranged to distinguish thermally induced deformation from mechanical strain.

How it's done:

Three separate strain gages are mounted on the test specimen and wired into a double bridge configuration. Variable resistors are used in the legs of the bridges to balance the outputs. The first gage is bonded to the test specimen surface in such a way that it responds to both thermally and mechanically induced strains. The second gage is attached to the test specimen surface with a silicone grease and compensates for the electrical changes of the first gage as a function of temperature. The third gage is bonded to a strip of material identical to the test specimen and the strip is thermally attached to the test specimen surface. This gage compensates for both electrical changes of the first gage and thermal expansion in the material. This causes the output between the first and third gage to respond only to mechanical deformation induced thermally in the material strip by temperature gradients occurring in the test structure.

In operation, the output between the first and second gages indicates the total thermal and mechanical strain change in the test structure, while the output

(continued overleaf)

between the first and third gages indicates only the mechanical component. By subtracting the mechanical strain from the total strain, the true thermal strain acting on the test structure is determined.

Notes:

1. This design can be reduced to a single bridge configuration employing the first gage in conjunction with either the second or third depending upon the conditions of the test and whether thermal measurements alone or mechanical measurements alone are desired.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland, 20771
   Reference: B66-10280

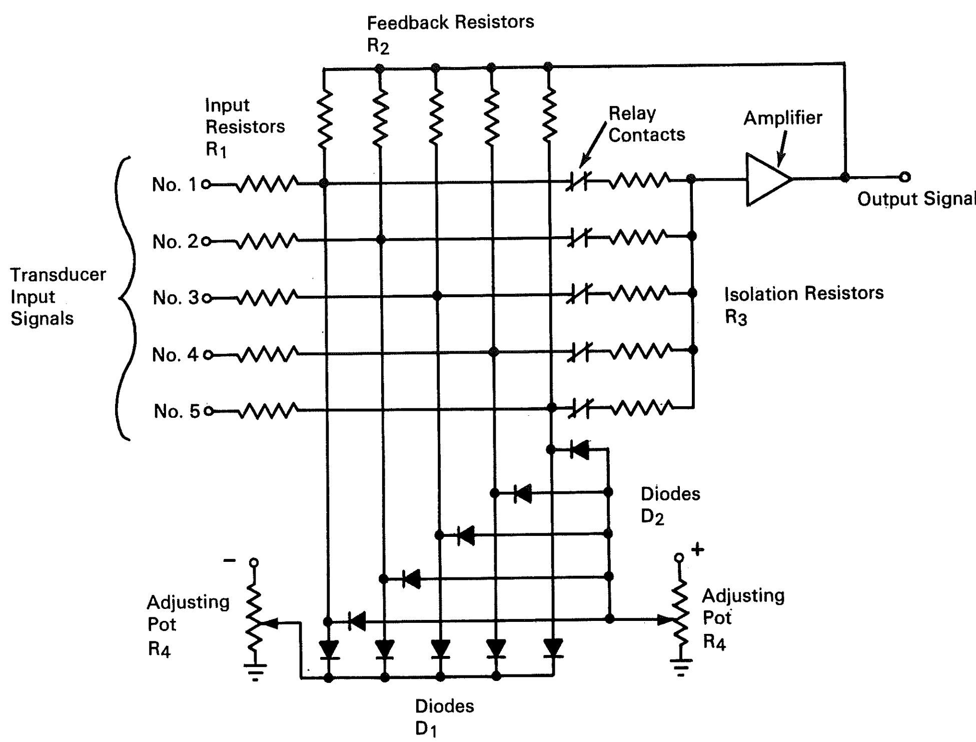
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Frank J. Cepollina
(GSFC-478)

NASA TECH BRIEF

Simple Circuit Provides Reliable Multiple Signal Average and Reject Capability



The problem:

The control of a system required that one function be monitored in a redundant manner by a number of transducers. It was necessary that these multiple signals be "averageable" to take individual deviations into account without shutting down the entire system because of such deviations.

The solution:

A summation average and reject circuit based on diode clamping.

How it's done:

The circuit uses an amplifier having separate transducer input resistors R_1, feedback resistors R_2, and isolation resistors R_3 for each signal to be averaged.

(continued overleaf)

Automatic reject action is provided by the positive or negative diodes (D_1 and D_2) at the R_1 and R_2 resistor junctions which clamp or short out the junction when a signal varies a sufficient amount from the average selected. The diodes D_1 and D_2 may be grounded or biased by the adjusting pots R_4 depending on how much deviation from the average is permissible before rejection is desired. Relay contacts are provided at the isolation resistors to allow the operator, from observation of instrumentation, to manually remove a failed signal from the averaging circuit.

Values of input and feedback resistance may be selected to provide gain or attenuation. The value of isolation resistance R_3 will affect the amount of signal deviation from the average before signal rejection occurs. The higher the isolation resistance value the less it will load the junction and the diode bias will significantly affect the range over which averaging occurs.

Notes:

1. A bias source with very low impedance must be used to prevent bias shift when the diodes conduct. The input and the feedback resistors must be high precision (preferably 0.1%) to ensure accurate averaging.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC-NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C. 20545
   Reference: B66-10282

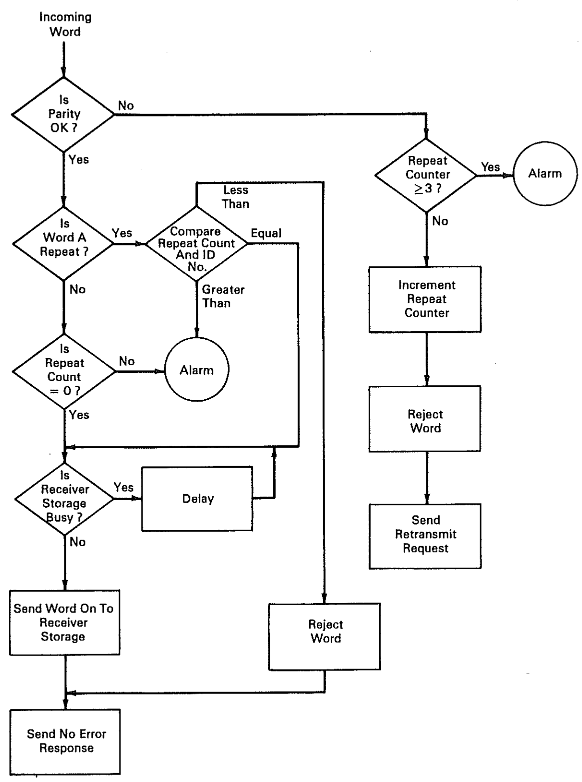
Patent status:

No patent action is contemplated by NASA.

Source: R. L. Openshaw
of Aerojet-General Corporation
under contract to
Space Nuclear Propulsion Office
(NU-0069)

NASA TECH BRIEF

Detection System Ensures Positive Alarm Activation in Digital Message Loss



The problem:

In many data transmission systems which use the block- or word-segmented data group, the transmitting terminal of the system is required to store the message long enough for it to be examined for error by the receiving terminal. After the examination, the receiving terminal transmits one of two possible messages to the transmitting terminal, instructing it either to retransmit the message (if an error was detected), or to erase it from storage (if there was no error), and permit the next message to be transmitted. As a result of errors in the transmission from receiver to transmitter, request for error retransmission could be improperly decoded as an erase request. This would result in the loss of the message from both the transmitting and receiving stations, and this loss of message might go undetected, despite the elaborate message bookkeeping schemes.

The solution:

A proposed LOWDS (Lost Word Detection System) that provides additional special identification for each

(continued overleaf)

message. Each transmitted message contains a *Message Identity* portion, which identifies the message as either an original (not previously transmitted) message, or as an n-times retransmitted message. The receiver can then detect any case where a request for retransmission was not fulfilled, and activate an alarm, indicating digital message loss as a result of an undetected error in a response message from the receiver to the transmitter.

How it's done:

At the receiving terminal the error checking circuits examine the incoming message from the transmitting terminal. If the message contains an error, a retransmit request is generated and sent back to the transmitting terminal. At the same time the receiving terminal notes the fact that following a given period the message must be retransmitted. This retransmission must have a message identity designating it as the first requested retransmission. If a message with any other message identification is received, it indicates that the original message has been lost and activates an alarm.

In detail, the incoming word is first checked for parity. If the parity check is good the word is examined to see if it is a repeat. If the ID serial number is "00", then the word is a new one and the repeat counter (which keeps track of the number of repeat requests sent by the receiving terminal) is checked to see if a repeat was requested. If a repeat was requested then a word has been lost and the alarm is activated. If the repeat counter also reads "00", then the word is a new word which is accepted by the receiver, and a signal is sent to the transmitting terminal, acknowledging an error free reception. The transmitter is then free to transmit the next word and erase the previous word from its storage.

If parity is good and the word is a repeat, then the repeat counter is compared to the ID serial number of the word (which shows which order of repeat it is). If the number in the repeat counter is greater than the ID serial number, then a word has been lost and the alarm is activated. If the number in the repeat counter is less than the ID serial number, a repeat word was sent when a new word was requested. The word is rejected and a no-error-detected response is sent to the transmitting station.

If the number in the repeat counter is equal to the ID serial number, then the word received is the proper order of repeat and is accepted by the receiver, a no-error response is sent to the transmitting terminal, and the repeat counter is cleared.

Notes:

1. This system is part of a digital data link system providing computer-to-computer data transfer where an undetected loss of any message cannot be tolerated.
2. The *Message Identity* portion of the message and the two responses from the receiver to the transmitter (a no-error-detected response or a request for retransmission) may be protected by standard error correction codes to further decrease the probability of an undetected communication error.
3. If the equipment to which the receiver is attached is too busy to accept an error free message, the receiver can then call for a retransmission of the message. This action inserts a delay in the system to permit the busy state to terminate. This feature requires very little additional equipment since it makes use of the standard LOWDS retransmission facility, and eliminates the requirement for a one-word storage buffer.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Western Operations Office
   150 Pico Boulevard
   Santa Monica, California 90406
   Reference: B66-10287

Patent status:

No patent action is contemplated by NASA.

Source: Paul Bokros, Albert Burstein,
and Edward D. Hewitt
of Radio Corporation of America
under contract to
Western Operations Office
(WOO-208)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Large Capacitor Performs as a Distributed Parameter Pulse Line

The problem:

In the development of a pulsed plasma accelerator for space propulsion application, a capacitor bank consisting of a number of capacitors in parallel has been used as the energy storage element. Current from this source is pulsed directly through the plasma between the electrodes of the system. For certain applications a constant current lasting for a specified period of time is desirable. Independent control over absolute magnitude of the current and current pulse duration may also be desirable.

The solution:

Capacitors of extended foil construction having single unit capacitance as great as 180 microfarads, with self inductance of approximately 10^{-9} henries, and capable of handling operating voltages greater than 10 kv. In operation these capacitors perform as a distributed parameter pulse line in which current, amplitude, and period are readily controlled.

How it's done:

The capacitor is made essentially the same as the conventional extended foil construction, but with particular care being taken to avoid parasitic inductance in the connections. What is of importance here is that the transit time of the electromagnetic wave is longer than the capacitor charge–discharge time as determined by actual discharge conditions. The capacitor electromagnetic wave that is discharging the foils propagates radially, the direction of propagation being determined by the location of the return current strap. A set of equations is derived to calculate the values of the distributed parameters (inductance, capacitance, impedance, and pulse time). The calculated values of line impedance and pulse time are in close agreement with experimentally measured values.

Notes:

1. In this type capacitor, the output waveform may be tailored to obtain more efficient capacitor energy transfer to the load.
2. This design should be of interest to manufacturers of energy storage systems and magnetic field devices.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10291

Patent status:

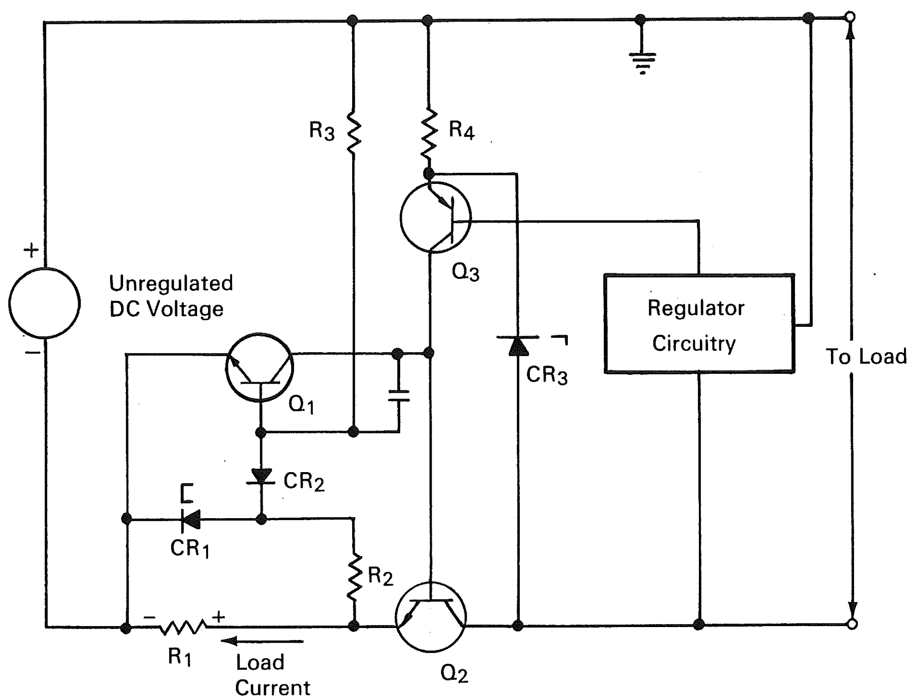
No patent action is contemplated by NASA.

Source: Terence J. Gooding et al
of General Dynamics/Astronautics
under contract to
Lewis Research Center
(Lewis-176)

Category 01

NASA TECH BRIEF

Circuit Protects Regulated Power Supply Against Overload Current



The problem:

To protect a low voltage transistorized dc regulator from damage by excessive load currents. In some applications, a single load fault can disable an entire system by disabling the regulators. Current threshold detectors have employed zener diodes and the voltage characteristics of transistor base–emitter junctions but these have not achieved sharp detection and current limiting.

The solution:

A sensing circuit in which a tunnel diode controls a series regulator transistor. When a fault occurs, the faulty circuit is limited to a preset percentage of the current when limiting first occurs.

How it's done:

R_4, Q_3, and CR_3 form the regulator series stage driver and Q_2 is the regulator series element. The overload circuit is composed of R_1, R_2, R_3, CR_1, CR_2, and Q_1, and functions by shunting the base current of Q_2 through Q_1 in case of overload, thereby shutting off Q_2 and limiting the fault current. The volt-ampere characteristics of CR_1 are used to provide the voltage threshold detection. The voltage across R_1 is used to detect the magnitude of the load current.

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When the load current is just below the limiting level, current through R_3 plus current through R_2 is just below the threshold point of CR_1. The base-to-emitter voltage of Q_1 is the sum of voltages across CR_1 and CR_2 and the current through R_3 is such that the voltage across CR_2 is about 400 mv. The voltage across CR_1 is at 50 mv and the base-emitter voltage of Q_1 is 450 mv which is not sufficient to turn on Q_1. This is the normal mode of overload curcuit/regulator function.

When the load current causes the peak-point current of CR_1 to be exceeded, it causes the base-emitter voltage of Q_1 to turn that transistor on. As a result, current through R_3 now flows into the base of Q_1 and the collector current of Q_3 flows into Q_1 rather than the base of Q_2 so that Q_2 turns off and limits the current to the regulator, the collector-emitter (saturated) voltage of Q_1 being less than the threshold base-emitter voltage of Q_2. The regulator series element being turned off, current through R_1 decreases, allowing current through CR_1 to decrease. When the current through CR_1 drops below its valley-point current, the overload circuit returns to its original state. If the overload is still present, the cycle is repeated, alternately cutting off Q_2 and continuing to limit overload current to the regulator until the fault in the load is corrected. Value of the capacitor controls frequency of the series stage cycle.

Notes:

1. Typical changes of the threshold detection current are $\pm 10\%$ over a range from 0° to +70°C. Any change with temperature in the base-emitter voltage threshold of Q_1 is compensated for by a like change in the threshold voltage of CR_2.
2. This circuit provides sharp detection of overload currents at very low voltage levels and has limited short circuit currents to less than 10% more than the detector (CR_1) threshold current.
3. The circuit shown uses a germanium tunnel diode but will perform satisfactorily with one of silicon.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10292

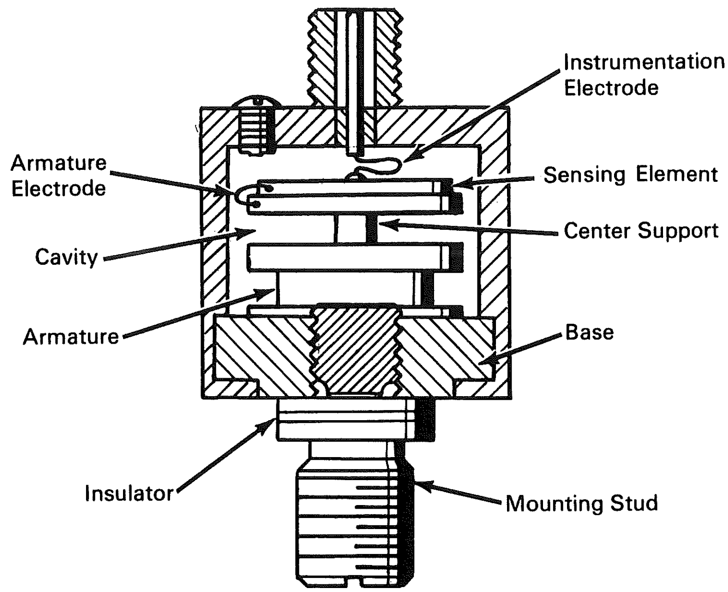
Patent status:

No patent action is contemplated by NASA.

Source: H. B. Airth
of Westinghouse Electric Corporation
under contract to
Goddard Space Flight Center
(GSFC-453)

NASA TECH BRIEF

Damping Technique Gives Accelerometer Flat Frequency Response



The problem:

In tests of large booster rockets, very high shock pulses on the frame of the propulsion system cause an accelerometer to oscillate or "ring" at its fundamental resonant frequency, causing an electrical overload of associated electronics. This results in the loss of useful data for a finite period after the "ringing" occurs.

The solution:

A piezoelectric accelerometer that achieves a flat response over a wide frequency range, including the instrument's fundamental resonant frequency, in high acoustic environments, by a viscous damping technique.

How it's done:

The accelerometer body is a hollow cylinder and is attached to the surface being vibrated by a two-part mounting stud that is intersected by an electrical insulator. Within the cylinder, a base mounts a circular metal armature that is smaller in diameter than the inside cylinder walls by a precise amount, so that an annular passage exists between armature and cylinder wall. A piezoelectric sensing element is cemented to and in intimate contact with the upper face of the armature and is connected to the armature by an electrode. A second electrode connects the sensing element to external instrumentation. The cavity within the accelerometer body is filled with a viscous silicone damping fluid.

In use, the accelerometer armature responds to shock or acceleration forces by flexing about its center support. This flexes the attached piezoelectric sensing element, inducing a voltage in it proportional to the

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applied external force. The voltage is fed to appropriate instrumentation by the electrode and the external force is measured. Vibrations set up in the armature are quickly damped out by the viscous silicone damping fluid, thus making the instrument immediately available for subsequent force measurement.

Notes:

1. Size of the annular space between the armature and body wall is critical because fluid flow through the space must be an unchoked but restrained laminar flow as the armature is flexed.
2. This device measures random or sinusoidal vibration from 20 to 10,000 cps in the presence of acoustic levels of 150 to 160 db. Acoustic response is equivalent to 0.05 g at 140 db.

Patent status:

Title to this invention, covered by U.S. Patent No. 3,170,076, has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to Gulton Industries, Inc., 212 Durham Avenue, Metuchen, New Jersey.

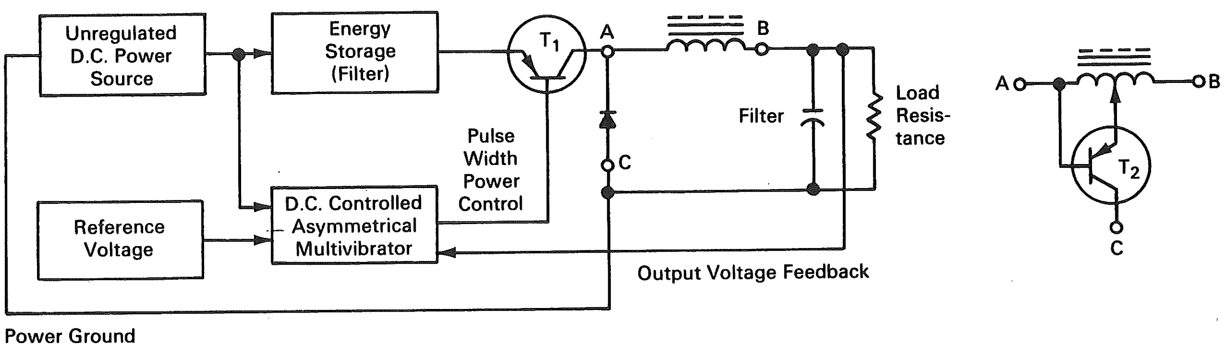
Source: Thomas Wing
of Gulton Industries, Inc.
under contract to
Marshall Space Flight Center
(M-FS-471)

July 1966

Brief 66-10295

NASA TECH BRIEF

Substituting Transistor for Diode Improves Rectifying Means



The problem:

In rectifiying an alternating current, prior art has used silicon diodes which have exhibited a forward voltage drop and relatively slow turnoff time. The former disadvantage is important when the forward voltage drop is a significant proportion of the total load voltage. The latter disadvantage restricts the repetition rate of the alternating voltage to a low value.

The solution:

An unusual transistor connection that substitutes for the diode and allows significantly higher repetition rates without increasing power loss.

How it's done:

The improvement is made by substituting circuit A-B-C in the right figure for circuit A-B-C in the left figure. In operation, T_1 is pulsed on. This creates a magnetic field in the transformer and supplies the load current. Transformer action also reverse biases T_2 at this time. As T_1 turns off, the magnetic field in the transformer collapses and turns on T_2. The current from the collapsing field flows into the collector, which is the inverted connection of T_2 that is employed to get good voltage breakdown characteristics for T_2 when T_1 is on. Saturation voltage is very low in this configuration and results in an equivalent diode of very low forward voltage drop.

Notes:

1. Operation speed is improved by a factor of 10 or more when a given diode is replaced by this transistor circuit.
2. The circuit on the left, when converting 28 volts to a load voltage of 4 volts, operated at less than 69% efficiency. When it was replaced with the circuit A-B-C in the right figure, an efficiency of 80% was achieved.
3. This circuit should be beneficial for use in power converters where the load voltage is low.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10295

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Ronald M. Muller
(GSFC-474)

July 1966 Brief 66-10300

NASA TECH BRIEF

Computer Program Determines Gas Flow Rates in Piping Systems

The problem:

Calculating the steady state flow of an ideal compressible gas in a complex piping system is normally a tedious job. A wide variety of calculations must be performed to account for such diverse system elements as orifices, heat exchangers, area changes, constant loss factor elements, adiabatic pipes, diabatic pipes, radius bends, and mitre bends.

The solution:

A computer program that will calculate the steady state flow characteristics of a piping system containing any of the eight standard elements. The program calculates and prints out the stagnation and total temperature, static and total pressure, loss factor, and forces on each element. The output data also includes flow rate and approximate volume through each subsystem.

How it's done:

The program user supplies a description of the system and of each element in the proper format and the temperature at each inlet of the system. If the system contains parallel paths of flow it is necessary to provide initial estimates of the flow rate for one or more of the branches. If the system involves heat transfer it is necessary to provide initial estimates of the temperature at each internal branching point and exit.

Flow rates are calculated from known values of the system, starting at the downstream end. Where all pertinent values are known, the continuity equation and equations relating total and stagnation temperatures and pressure are used. Where estimated values are employed, calculations are made by more than one method and errors are thereby minimized.

Notes:

1. The program is coded for the Fortran II, version 3 monitor in assembly language for the IBM 7094 computer. The program can handle systems containing up to 25 subsystems connecting not more than 25 junctions. In addition, three times the number of subsystems plus the total number of elements must not exceed 1000.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10300

Patent status:

No patent action is contemplated by NASA.

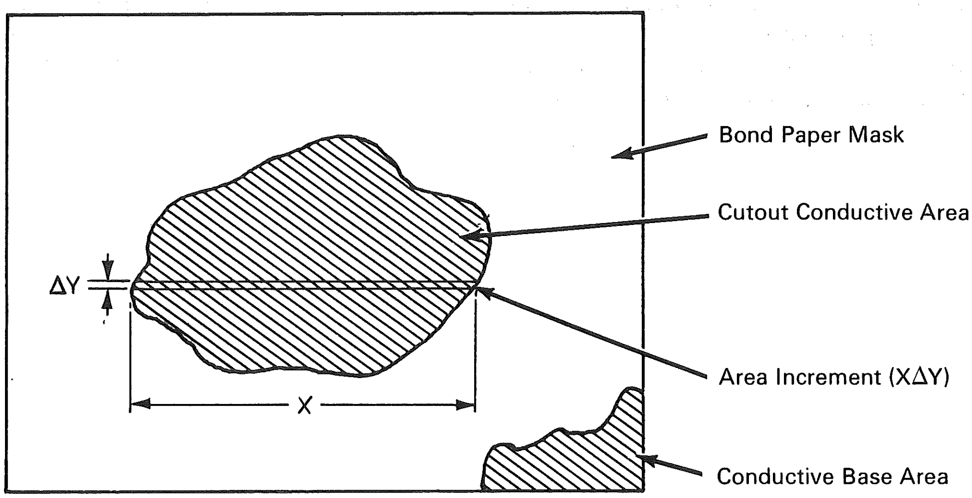
Source: Richard Franke
of the Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-443)

Category 01

July 1966 Brief 66-10306

NASA TECH BRIEF

Instrument Calculates Moments of Inertia of Complex Plane Figures



The problem:

To provide an instrument that will calculate distributive-area properties, such as centroids and moments of inertia, of complex or irregular plane figures representing cross sections of structural members. For figures of this type, the required properties cannot be obtained from tables or calculated analytically, as in the case of simple geometrical figures. Manual methods, which yield approximations of the true area properties, are laborious and time consuming.

The solution:

A calculator consisting of a narrow field scanner coupled with a relatively simple preprogrammed computer.

How it's done:

The calculator uses a servoed X–Y plotter, with a linear sweep voltage applied to one input axis and a linear step voltage to the other input axis, to scan the area in small incremental steps. The output data from the scanner are fed to an analog computer, which performs a series of discrete summations, closely approximating the exact integration, to yield the value of the desired property (e.g., centroid or moment of inertia).

The area whose properties are to be computed is cut from a sheet of bond paper and the remaining outline is cemented as a mask on an electrically conductive base. The exposed conductive area is then used for incremental scanning. A linear sweep voltage causes the probe of the X–Y plotter to scan across the conductive area in the X direction, and a linear step voltage applied at the end of each sweep causes the probe to step a constant small increment (ΔY) in the Y direction. In this manner, each incremental area (XΔY) is swept out over the entire conductive area. The stepping voltage at any given time corresponds to the distance from a selected arbitrary reference axis

(continued overleaf)

(which serves as a base for calculation of the desired property, e.g., centroid or moment of inertia) to the incremental area being swept out. As the probe makes one sweep across the surface, a sweep voltage pulse will be generated as long as the probe is in contact with the conductive surface. Since the probe sweeps at constant speed, the time of the sweep voltage pulse is proportional to each incremental area. The outputs from the plotter and the conductive surface are fed to a preprogrammed analog computer which uses an integrator to compute the desired distributed-area property represented by the conductive area. To determine the area property with respect to an orthogonal reference axis, the step and sweep voltage input axes of the plotter are interchanged

Notes:

1. Tests have shown that the average time for making a mask and running a computation with respect to two orthogonal axes is approximately 15 minutes. The computations are accurate to within 2 percent when the area is scanned in 0.01-inch steps. Greater accuracy can be obtained using shorter steps in the scanning process.
2. An electro-optical scanner or pure mechanical scanner can be used in place of an X–Y plotter.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10306

Patent status:

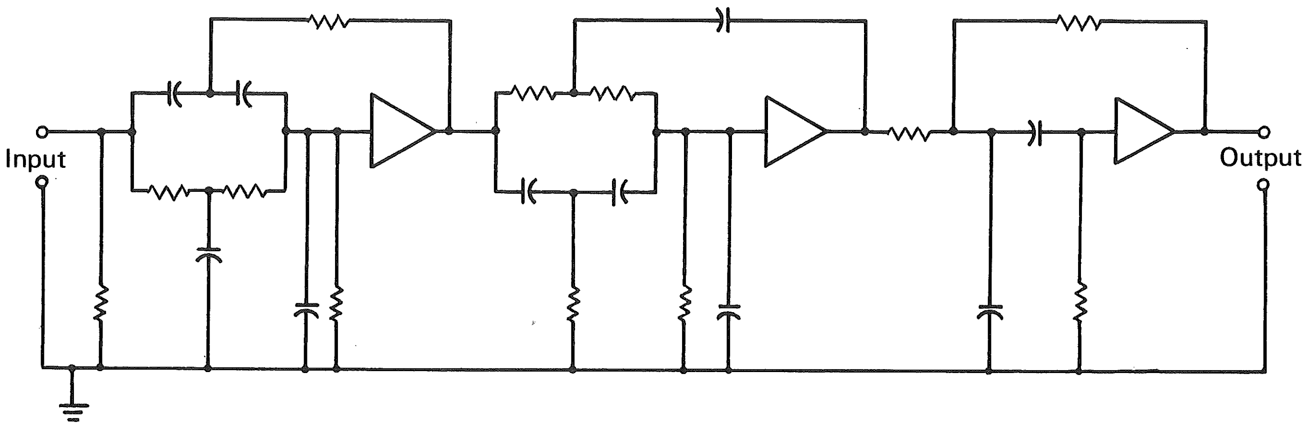
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Wilbur J. Myers
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-628)

July 1966 Brief 66-10309

NASA TECH BRIEF

High-Performance RC Bandpass Filter Is Adapted to Miniaturized Construction



The problem:

To design a sixth-order unsymmetrical bandpass filter suitable for use in integrated circuits.

The solution:

A bandpass filter using RC networks (in place of LC networks) in a form suitable for integrated circuits. The circuit consists of three stages of amplification with additional resistive and capacitive components to obtain the desired characteristics.

How it's done:

Three stagger-tuned stages are used as the basic structure with modifications to allow for the asymmetric infinite attenuation points. Each stage uses passive RC components and an amplifier that acts as an ideal voltage-controlled voltage source of low gain. Parallel ladder networks are used in two of the stages, both to provide the finite zeros and as feedback configurations to realize the desired complex conjugate poles. These networks permit completely independent selection of the pole and zero positions. A somewhat simpler RC network in the third stage provides the zeros at the origin and at infinity, and the third set of complex conjugate poles.

The amplifiers are suitable for cascade connection, without the use of coupling or bypass capacitors. In addition, they have very high gain stability, an input impedance exceeding 20 megohms, and an output impedance less than 20 ohms. Each amplifier uses 3 transistors and 5 resistors. In its present form, the amplifier has a frequency response of dc to 5 mc. The networks used require gains of between 1 and 4, and the amplifier provides an open-loop voltage gain of greater than 1,000, thereby allowing excellent stability as a result of the feedback employed.

The RC circuit has exceeded a comparable LC circuit in notch rejection at 5 kc and 15 kc, and produced a gain of 500 in the pass band, which is 2 kc wide, centered at 10 kc. Temperature tests have shown less than 1 percent overall system gain change from room temperature to 100° C.

(continued overleaf)

Notes:

1. The primary advantages of the active RC filter network are in the reduction in size and weight achieved and in the elimination of magnetic materials. The latter advantage is particularly important in instruments used for measuring very weak magnetic fields.
2. Even without using integrated circuitry techniques, this complete filter–amplifier could be packaged in a 1-inch cube using off-the-shelf, discrete components.
3. Further information concerning this innovation is given in "The Design of High Performance Active RC Bandpass Filters," by William J. Kerwin and L. P. Huelsman in a paper for the 1966 IEEE International Convention March 21-26, 1966, New York, N.Y. Inquiries may also be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10309

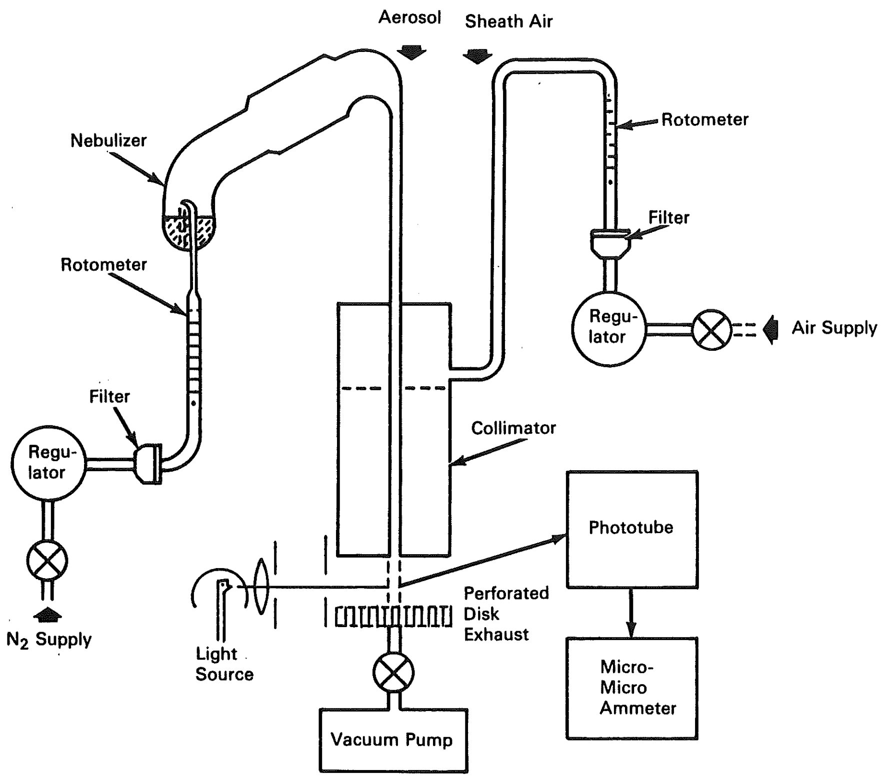
Patent status:

No patent action is contemplated by NASA.

Source: (ARC-60)

NASA TECH BRIEF

Solvent Residue Content Measured by Light Scattering Technique



The problem:

In cleaning large vessels, volatile organic solvents will leave traces of nonvolatile residue (NVR) that can cause system problems if above a certain concentration. Measurement of NVR in trichloroethylene, a typical solvent for cleaning large vessels, has previously been by the tedious and time consuming gravimetric method.

The solution:

A system that converts the NVR-bearing solvent to a fine aerosol and passes the aerosol between an optically focused light beam and a photodetector that is connected to standard amplifying and readout equipment.

How it's done:

The solvent containing the NVR is filtered to re-

(continued overleaf)

move all insoluble particles that would interfere with the analysis. The filtered solvent is then nebulized to a fine spray that is warmed slightly to evaporate most of the volatile solvent and leave a residual aerosol of the NVR. This residual aerosol is passed through a collimator that provides a clean, particulate-free air sheath around the aerosol filament as the filament passes through a light beam that is focused on a light-scattering photometer. The photometer produces an electrical signal that is directly related to the concentration of NVR in the solvent.

Notes:

1. A calibration curve for this nebulizer–light scattering photometer system was obtained by nebulizing standard volatile solutions containing known amounts of NVR as determined by the gravimetric method.
2. This system provides numerical cleanliness data on fluid tanking and distribution systems.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10320

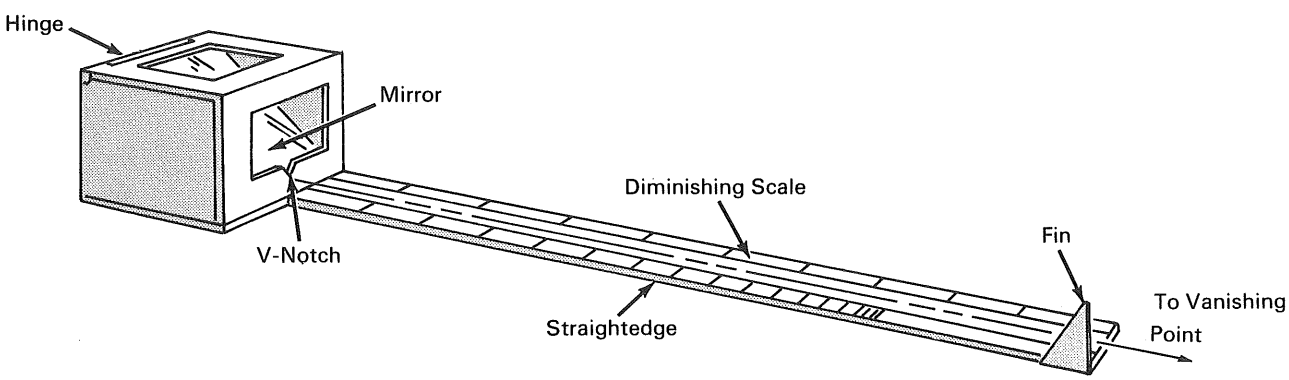
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Donald K. Werle and Martin J. Salkowski of Illinois Institute of Technology Research Institute under contract to Marshall Space Flight Center (M-FS-850)

NASA TECH BRIEF

Instrument Transmits Vanishing Point to Illustration Point



The problem:

To transmit the vanishing point of an illustration to a particular point on the illustration when drawing two- and three-point perspective. In large work, especially, the vanishing point will be at an appreciable distance from the illustration. Commercially available aids, such as perspective grids and boards, are not satisfactory for such work.

The solution:

An instrument that transmits the vanishing point to a point on a diminishing scale that also serves as a straightedge.

How it's done:

A mirror, mounted at a 45° angle is mounted in a housing with a window in its top and another in one of its sides. The top window is used for sighting into the mirror, through the side window, that has a V-notch in its bottom center, along the diminishing scale to a sighting fin mounted on the end of the scale. By aligning the selected vanishing point with the sighting fin and center of the V-notch, the vanishing point is transmitted to a point on the diminishing scale. The diminishing scale is used both as a straightedge and foreshortening medium, its drawing edge being aligned with the V-notch and sighting fin. The housing is hinged in a manner to facilitate cleaning of the mirror.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
Reference: B66-10324

Patent status:

No patent action is contemplated by NASA.

Source: Manuel M. Alvarez
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-267A)

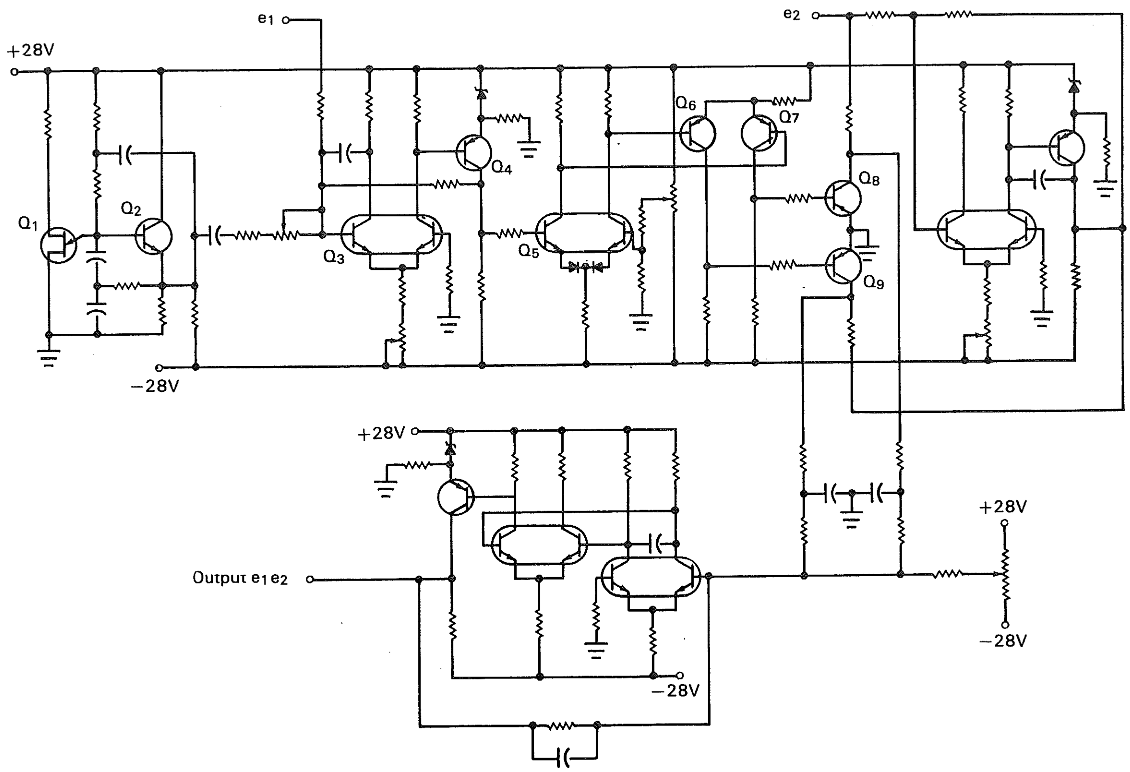
Category 01

July 1966 Brief 66-10331

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Circuit Provides Accurate Four-Quadrant Multiplication



The problem:

To design a circuit that will provide four-quadrant multiplication at frequencies ranging from dc to 100 cps. The circuit must consume little power and have an accuracy of approximately 1 percent.

The solution:

A solid state circuit using pulse-width and -height multiplication techniques.

How it's done:

The circuit uses ground referenced inputs and provides a ground referenced output. Transistors Q_1 and Q_2 generate a linear sawtooth waveform at a repetition rate of 3 kc. This sawtooth waveform is then fed into a closed-loop dc amplifier and summed with multiplier input e_1. The e_1 input is dc-coupled and the sawtooth waveform is ac-coupled to allow the sawtooth to be shifted at near ground level by the dc

(continued overleaf)

input. The output of the amplifier, obtained at the collector of Q_4, is dc-coupled into a high-gain switching amplifier which controls the multiplying switching transistors Q_8 and Q_9. The switching amplifier switches when the input-biased sawtooth waveform crosses zero.

The e_2 multiplier input is applied to the collector resistor of Q_8. This input is also inverted and applied to the collector resistor of Q_9. The output e_1e_2 of the multiplier is obtained by summing and filtering the output of the two switching transistors. When e_1 is zero, the sawtooth at the output of Q_4 is symmetrical about ground level and turns Q_8 and Q_9 on and off for equal time increments. Thus the output is zero regardless of the value of e_2. Similarly, when e_2 is zero, the output is zero for all values of e_1. When inputs e_1 and e_2 have any values other than zero, the switching duty cycles of Q_8 and Q_9 are changed in proportion to these inputs to provide an output equal to the product of e_1 and e_2.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California 90406
Reference: B66-10331

Patent status:

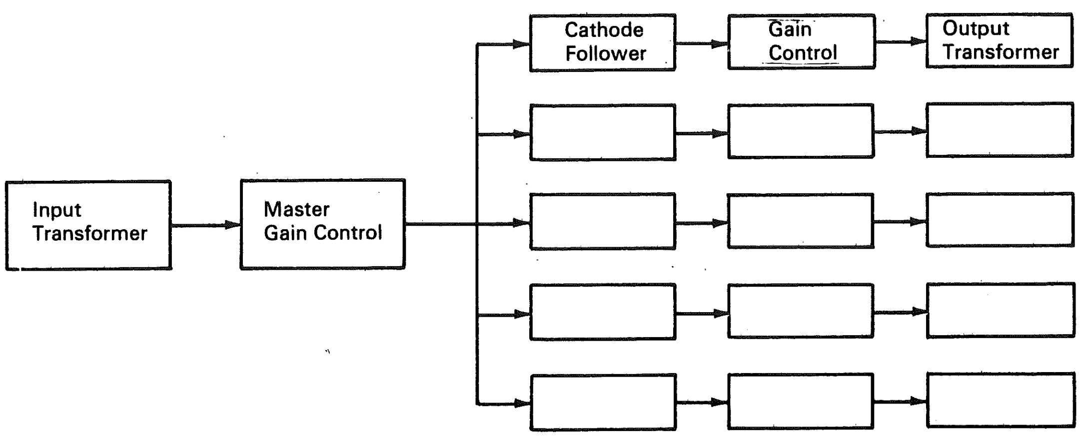
No patent action is contemplated by NASA.

Source: G. F. McGowan
of Martin-Marietta Corporation
under contract to
Western Operations Office
(WOO-272)

August 1966 Brief 66-10308

NASA TECH BRIEF

Microphone Multiplex System Provides Multiple Outlets from Single Source



The problem:

To use a single source of audio signal to provide multiple audio outputs that can be connected to many low impedance microphone inputs simultaneously.

The solution:

A microphone multiplex system that will accept a signal from a single source (a program mixer or any 600-ohm line) and provide any number of low impedance outputs at microphone level with complete isolation between output channels.

How it's done:

The multiplexer consists of a single input transformer (600-ohm balanced or unbalanced bridge) for accepting any standard line input. The secondary of this transformer is connected to a master gain control and through isolation resistors to parallel cathode followers. The cathode followers give complete isolation between channels and connect through individual gain controls to separate output transformers. The levels of the master gain control and the individual gain controls are adjusted so that the combined loss will be approximately 55 db at each output. Approximately 65% of this loss is taken at the individual gain controls to keep the signal-to-noise ratio and distortion at an optimum.

Notes:

1. The multiplexer meets all broadcast standards.
2. It has a response of 30 cps to 15 kc with less than 1.0% distortion at −35 db output.
3. Any input or output may be converted to high impedance by elimination of the associated transformer.
4. The input can be taken directly from a microphone with the addition of a preamplifier stage.
5. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10308

(continued overleaf)

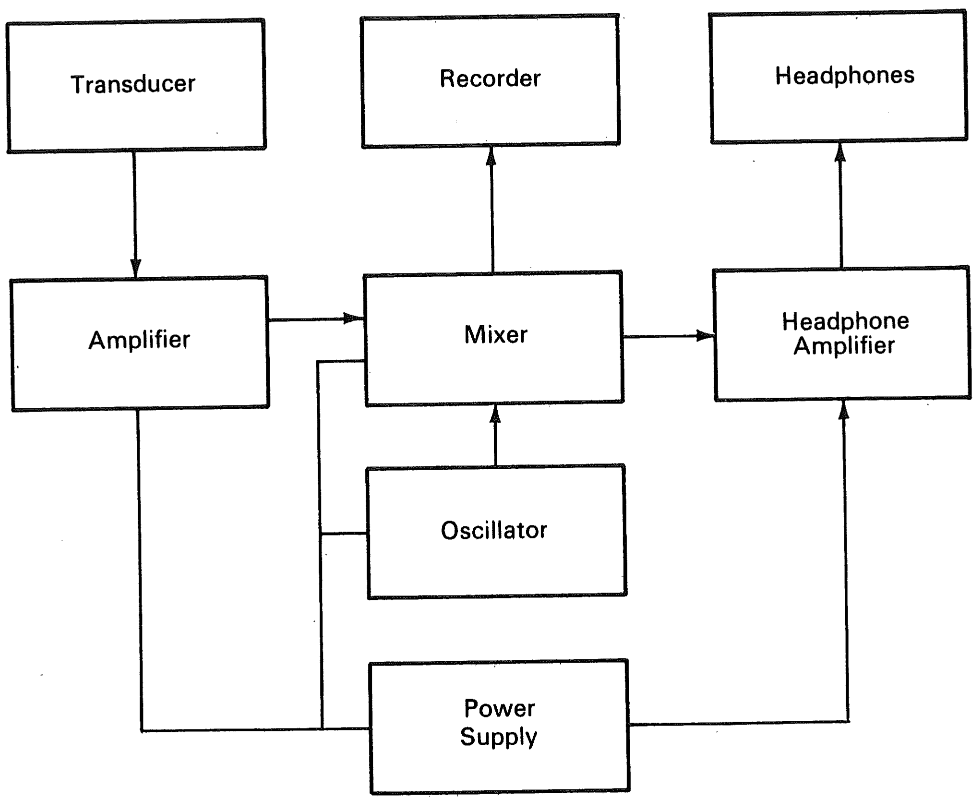
Patent status:

No patent action is contemplated by NASA.

Source: Raymond E. Lauver
(GSFC-426)

NASA TECH BRIEF

Ultrasonic Emission Method Enables Testing of Adhesive Bonds



The problem:

To investigate the applicability of the acoustic emission effect (the generation of acoustic energy by mechanically stressed materials) as a means for testing of adhesive bonds.

The solution:

Preliminary tests on a number of adhesive bonds subjected to tensile stresses indicate that detection of the acoustic energy emitted by the bonds at frequencies above 16 kilocycles per second can be used as a method for determining bond strength.

How it's done:

The test adhesive is applied to form a bond between two small aluminum blocks. A piezoelectric transducer is then secured to one of the blocks and the specimen is mounted in a tensile tester. The transducer,

(continued overleaf)

used to detect the acoustic energy generated by the adhesive bond as it is subjected to an increasing tensile stress, is a disk of barium titanate–lead zirconate, having a frequency response up to more than 100 kilocycles per second.

The output of the transducer on the stressed specimen is amplified with a gain of 5000 at a center frequency of 31 kilocycles per second and a bandwidth of 5 kilocycles per second, allowing energy in a band of 28 to 32 kilocycles per second to be amplified and processed. The input of the amplifier handles large signals below 28 kilocycles per second without distortion, allowing noise pulses of less than 28 kilocycles per second either from the test fixture or a shop environment to be attenuated and thus not disturb the system. The amplifier output is fed to a mixer along with a signal from a 32 kc oscillator. The mixer produces the sum and difference frequencies of the two inputs, although only the difference frequency is used. The output frequency of the transducer is now translated to a range of 100 cycles to 4 kilocycles per second. This signal is detected and used to drive a recorder to plot average frequency as a function of applied stress (monitored in a separate channel) in real time. Thus the data can be interpreted while the sample is being stressed. A set of headphones may also be connected to the mixer to enable an operator to listen to the acoustic signals generated by the system. These signals can easily be distinguished from the noise generated by the test stand or environment. The stressed adhesive bond produces high-pitched crackling sound pulses of very short duration.

Notes:

1. This method has been found useful in measuring adhesive bond strengths on metal honeycomb core panels. Tests with phenolic cores, however, indicate that this material introduces noise which masks acoustic signals generated by the adhesive bond.
2. The method may find application in predicting adhesive bond strengths on large structures, which are normally tested with hydraulic pressure or static stresses. For such measurements a relatively large number of transducers would be required to pinpoint the weak areas.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10341

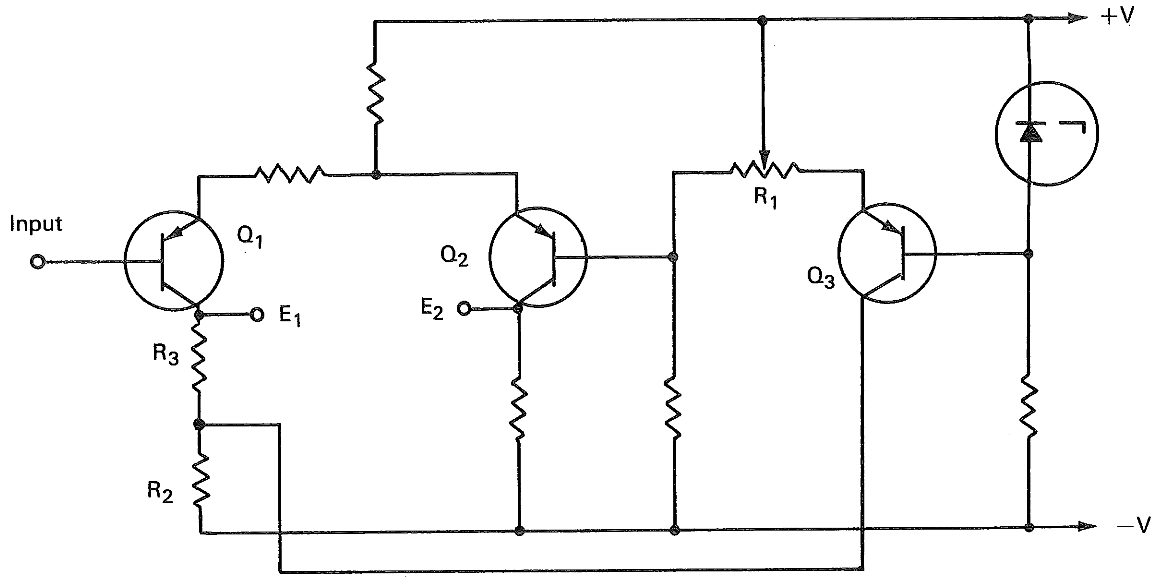
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Gerald Schmitz
and Louis Frank
of General American Transportation Corporation
under contract to
Marshall Space Flight Center
(M-FS-799)

NASA TECH BRIEF

Phase Inverter Provides Variable Reference Push–Pull Output



The problem:

To design a circuit that will provide a push–pull output referenced to a dc potential which can be varied without affecting the signal levels.

The solution:

A dual-transistor difference amplifier which provides the push–pull output, coupled with a feedback circuit which can vary the operating points of the transistors by equal amounts to provide variable reference potentials.

How it's done:

The difference amplifier consists of Q_1 and Q_2 and their associated components. The output signals, E_1 and E_2, appear at the collectors of the respective transistors and are 180° out of phase. The operating points of Q_1 and Q_2 with respect to either +V or −V are varied by varying R_1. If R_1 is varied in a direction that increases the positive bias on the base of Q_2, it will make Q_2 conduct less and cause E_2 to become more negative. Moving R_1 in this direction also increases the emitter resistance of Q_3 which causes Q_3 to conduct less, and decreases the current flow through the common resistor R_2. The voltage drop across R_2 and R_3 will therefore decrease, and E_1 will become more negative. The reference potentials, E_1 and E_2, have therefore varied in the same direction with respect to +V or −V, but the gains of Q_1 and Q_2 have not changed.

Notes:

1. This circuit was designed to drive a dc-coupled push–pull deflection amplifier, using R_1 as a centering control.

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2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
NASA Headquarters
400 Maryland Avenue, SW
Washington, D.C. 20546.
Reference: B66-10344

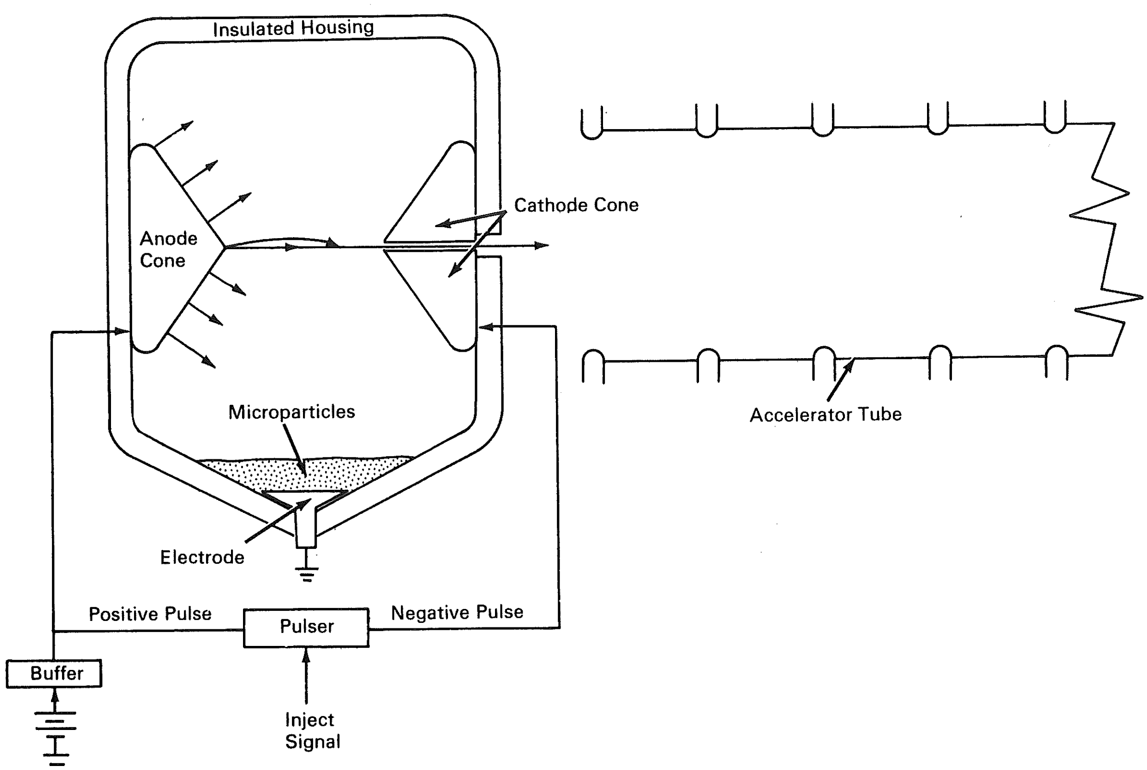
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Radio Corporation of America
under contract to
NASA Headquarters
(HQ-23)

NASA TECH BRIEF

Dust Particle Injector for Hypervelocity Accelerators Provides High Charge-to-Mass Ratio



The problem:

To design a device that will impart a high charge-to-mass ratio to microparticles and inject them into an electrostatic accelerator so that the particles will be accelerated to meteoric speeds. Existing microparticle injectors provide only approximately one-tenth the required charge-to-mass ratio, incorporate a fragile charging electrode, and do not control the injection angle. The accelerated particles are to be used for calibration of micrometeoric impact sensors and studies of erosion and luminous effects.

The solution:

An injector that employs relatively large masses in the anode and cathode structures with a relatively wide separation. This construction permits a large increase in the allowable injection voltages.

(continued overleaf)

How it's done:

Microparticles from the supply hopper are electrostatically agitated when a positive high-voltage injection pulse appears on the anode cone. When this pulse is removed, agitated microparticles are attracted and attached to the surrounding surfaces inside the housing by electrostatic attraction and by Van der Waals polarization forces. Many of these particles adhere to the anode, which normally remains at a low positive potential.

Particle injection into the accelerator tube occurs when an inject signal appears in the pulser unit. At this time, a positive high-voltage pulse appears on the anode simultaneously with a negative high-voltage pulse on the cathode cone. Particles attached to the anode are repelled in a direction perpendicular to the segment of surface upon which they were attached and are are accelerated and focused by the electric field between the anode and cathode cones. The strongest field exists in the region of the axis between the two cones. Particles in or near this region are collimated into the axial opening in the cathode cone and pass into the accelerator tube.

The particles attached close to the apex of the anode surface will acquire a higher positive charge than those attached to other portions of the anode, since the charge is proportional to the ratio of the radius of a particle to the radius at any given cross section of the cone. These particles will therefore be more strongly collimated into the cathode opening than other particles, which will either fall back into the supply hopper or be suspended elsewhere to await another electrostatic agitation.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10347

Patent status:

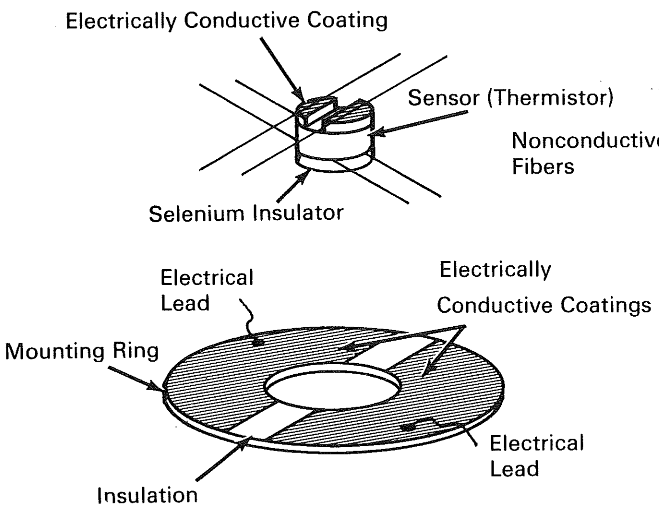
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Otto E. Berg
(GSFC-509)

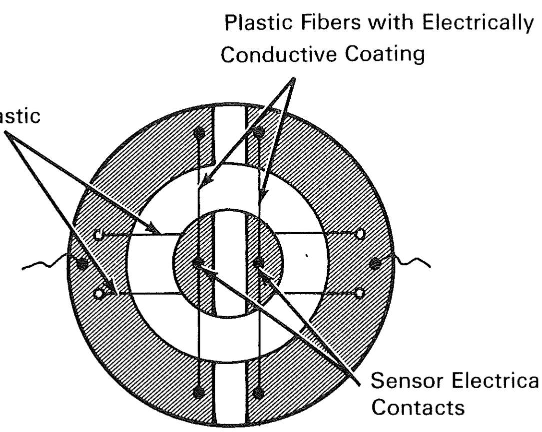
August 1966 B66-10349

NASA TECH BRIEF

Electrically Conductive Fibers Thermally Isolate Temperature Sensor



EXPLODED VIEW



TOP VIEW OF ASSEMBLY

The problem:

To devise a rugged mounting that will provide thermal isolation and an electrical path for an unbacked thermal sensor.

The solution:

Suspend the sensor in the center of a plastic mounting ring from four plastic (e.g., acrylic resin) fibers, two of which are coated with an electrically conductive material and connected to electrically conductive coatings on the ring.

How it's done:

Two sections of the upper surface of the mounting ring, made of insulating material, are coated with an electrically conductive material. Two of the plastic fibers are partially coated with a thin electrically conductive film and are secured both to conductive coatings on the sensor and the two electrically conductive sections of the mounting ring. Electrical leads to an external circuit are connected to these sections. Two untreated (nonconductive) fibers are secured to the underside of the sensor, which is then coated with a film of insulating material (e.g., selenium). The ends of these nonconductive fibers are secured to the mounting ring with a suitable adhesive.

Both pairs of fibers provide a vibration- and shock-proof support as well as thermal isolation for the sensor. The pair coated with an electrically conductive film offers a much higher thermal resistance than a solid conductor.

Note:

This type of sensor assembly may be permanently installed in large pieces of electrical equipment, such as in power stations, for temperature measurement under conditions where the time constant of the sensor is not critical.

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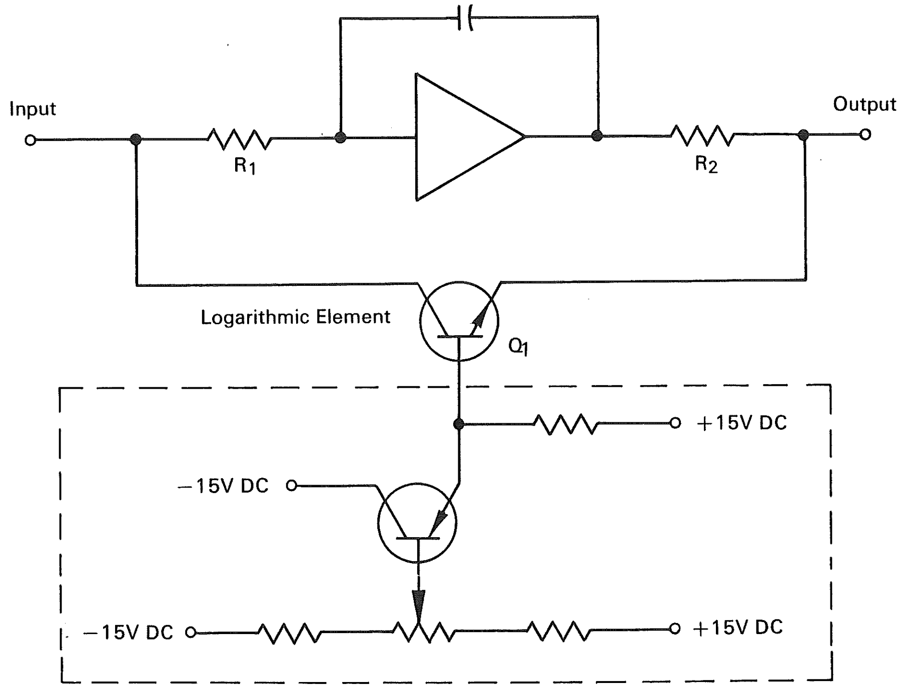
Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the Barnes Engineering Company, 30 Commerce Road, Stamford, Connecticut.

Source: Bruce Norton and Russel DeWaard
of Barnes Engineering Company
under contract to
Goddard Space Flight Center
(GSFC-456)

NASA TECH BRIEF

Transistor Circuit Increases Range of Logarithmic Current Amplifier



Temperature Compensating Network

The problem:

To design a logarithmic current amplifier capable of operating throughout a range of 10^{-12} to 10^{-2} amperes. Amplification through this range can be obtained by cascading amplifiers in incremental steps but this creates problems of physical volume, reliability, calibration, and difficult operation.

The solution:

A circuit that provides logarithmic amplification of an input range from 10^{-12} to 10^{-2} amperes by combining a commercially available amplifier with a silicon epitaxial transistor.

How it's done:

The principle of operation involves the placement of a logarithmic feedback element across the amplifier. The circuit operates on the transfer function of the silicon epitaxial transistor, Q_1 in which the output voltage is proportional to the log of the input current. Resistors R_1 and R_2 and the capacitor stabilize the circuit. That portion of the circuit within the dotted lines serves only to provide temperature compensation for Q_1. Input impedance is 10 megohms and input signal strength is 10^{-12} to 10^{-2} amperes.

(continued overleaf)

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
AEC-NASA Space Nuclear Propulsion Office
U.S. Atomic Energy Commission
Washington, D.C. 20545
Reference: B66-10350

Patent status:

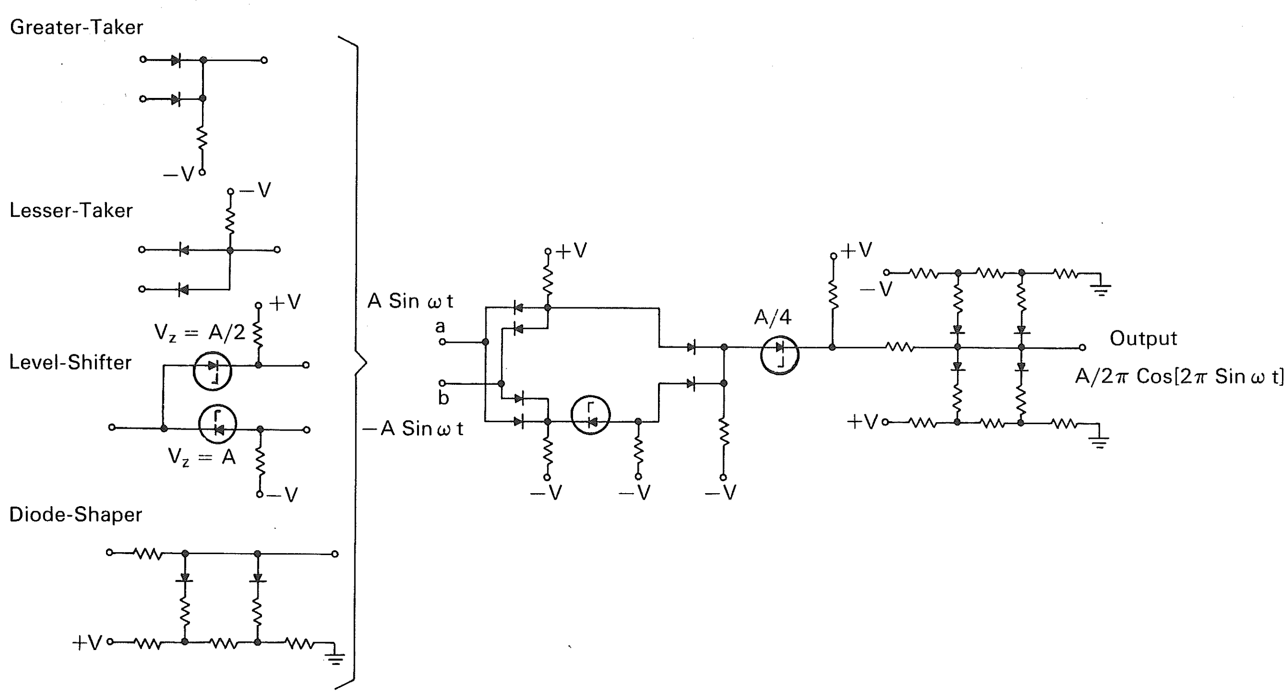
No patent action is contemplated by NASA.

Source: G. Gilmour
of Westinghouse Astronuclear Laboratory
under contract to
Space Nuclear Propulsion Office
(NU-0018)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Function Generator Eliminates Necessity of Series Summation



The problem:

To produce complex waveforms electronically without the necessity of series summation.

The solution:

A diode generator that produces functions of such complexity as sin(2πsinωt) and cos(2πsinωt) at frequencies down to zero cycles per second, using the combined outputs of four basic circuits.

How it's done:

This generator uses four building-block circuits to produce complex waveforms without the necessity of mathematically reducing the desired function to a series, and then summing the outputs produced by circuits generating the waveforms represented by the individual series elements.

Each of the four circuits alters the input signals in a particular way. One takes the greater part of both input signals (greater-taker), one takes the lesser part of both signals (lesser-taker), one splits the positive input into a positive and negative signal of the same waveshape (level-shifter), and one rounds off the top of the positive input (diode-shaper). For example, in the circuit diagram shown for the development of the function of cos(2πsinωt), the circuits are

(continued overleaf)

so connected that the characteristic input waveshapes of A$\sin\omega t$ at point a and $-$A$\sin\omega t$ at point b are modified sequentially by each circuit to result in an output waveform that very closely approximates the desired function.

The four basic circuits can be connected in various ways to produce the same waveform. They are sufficiently flexible that some resistors can be eliminated, some diodes can be replaced by emitter-follower transistor configurations, and the number of components in the diode-shaper can be varied, depending on the particular application of the generator. There are also combinations of circuits in which the forward voltage drops of the greater- and lesser-taker diodes are compensated by using two diodes where functionally only one is required.

Notes:

1. This highly specialized method of producing complex waveforms requires less power than present methods and uses simpler circuitry.
2. Many functions other than those indicated here can be implemented by an empirical synthesis of the same building-block circuits.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10351

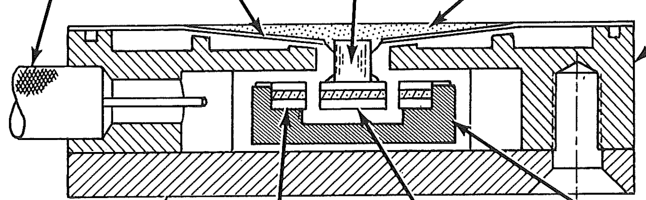
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

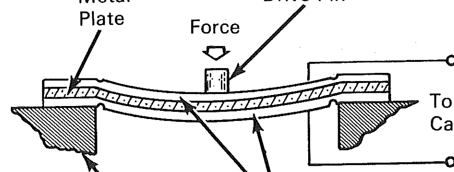
Source: David Mead, A. Joseph McCall,
and J. David Callan
of Hughes Aircraft Co.
under contract to
Goddard Space Flight Center
(GSFC-214)

NASA TECH BRIEF

Acceleration-Compensated Pressure Transducer Has Fast Response



TRANSDUCER ASSEMBLY



SENSING ELEMENT CONSTRUCTION AND MOUNTING DETAIL

The problem:

To design a flush-diaphragm transducer that will accurately measure small dynamic pressures when it is subjected to high accelerations and severe temperature environments. A flush-diaphragm design offers a potentially faster response to dynamic variations of low pressures than a conventional nonflush transducer which uses a short length of pressure tubing.

The transducer was required to meet the following specifications for measuring pressures on flat model surfaces in hypersonic shock tunnel tests:

Pressure range: 0.25 to 0.005 psid
Allowable pressure: 30 psi (without damage)
Natural frequency: 5,000 cps or higher
Acceleration response: Zero output
Temperature effects: Thermal insulation on exposed surface of diaphram to protect transducer from both conductive and radiative heat.
Size: Approximately 0.5-inch diameter and 0.25-inch thick

The solution:

A flush-diaphragm transducer employing piezoelectric crystals for measuring pressure and balancing out acceleration forces.

How it's done:

The pressure diaphragm is flat at the periphery and conical towards the center, where it is filled with an epoxy resin to form a flat surface. A thin layer of relatively soft material (e.g., natural rubber) is bonded to this surface to provide a heat barrier. Overload stops are provided behind the diaphragm to reduce maximum stress at the drive pin connection. The accelerometer crystal is connected to a weight rather than to a second diaphragm as in the conventional nonflush transducer. This weight is accessible for adjustment by removing the cover from the transducer. The provision for adjustment of the accelerometer weight allows compensation for the sensitivity difference between the pressure and accelerometer crystals. When the accelerometer and pressure assemblies are identical in mass and sensitivity, no output

(continued overleaf)

will result from acceleration forces acting on the transducer.

Each of the three sensing elements is constructed by cementing plates of oppositely polarized piezoelectric material (lead zirconate titanate) to the top and bottom surfaces of a thin metallic plate. The ends of the three elements are cemented to the transducer case. Each element thus acts as a simply supported beam loaded at its center by a concentrated force. The resulting charge displacement is in the same direction, since both the polarization and applied stress are reversed in direction between the top and bottom halves of the beam.

A single output cable is attached to the transducer because internal wiring is used to connect the electrical outputs of the pressure and accelerometer crystals in parallel opposition, rather than in series opposition as in the conventional design. Parallel wiring has the advantage that electrical leakage across the sensing elements is easily detectable at the transducer output. For the crystal capacitances used in this design the parallel wiring results in higher signals than series wiring when the length of the output cable exceeds 20 feet.

Notes:

1. Tests of the transducer mounted on flat model surfaces in hypersonic shock tunnel tests indicate that it affords adequate thermal protection for heating rates of 4.7 Btu per sq ft per sec at pressures of 0.0037 psia. Acceleration sensitivity was found to be low enough to allow the transducer to measure pressure on the windward side of models.
2. The rise time of this transducer was found to be about one-fifth that of a conventional nonflush transducer under the same test conditions.
3. The piezoelectric elements must be matched for high sensitivity to applied stress.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10353

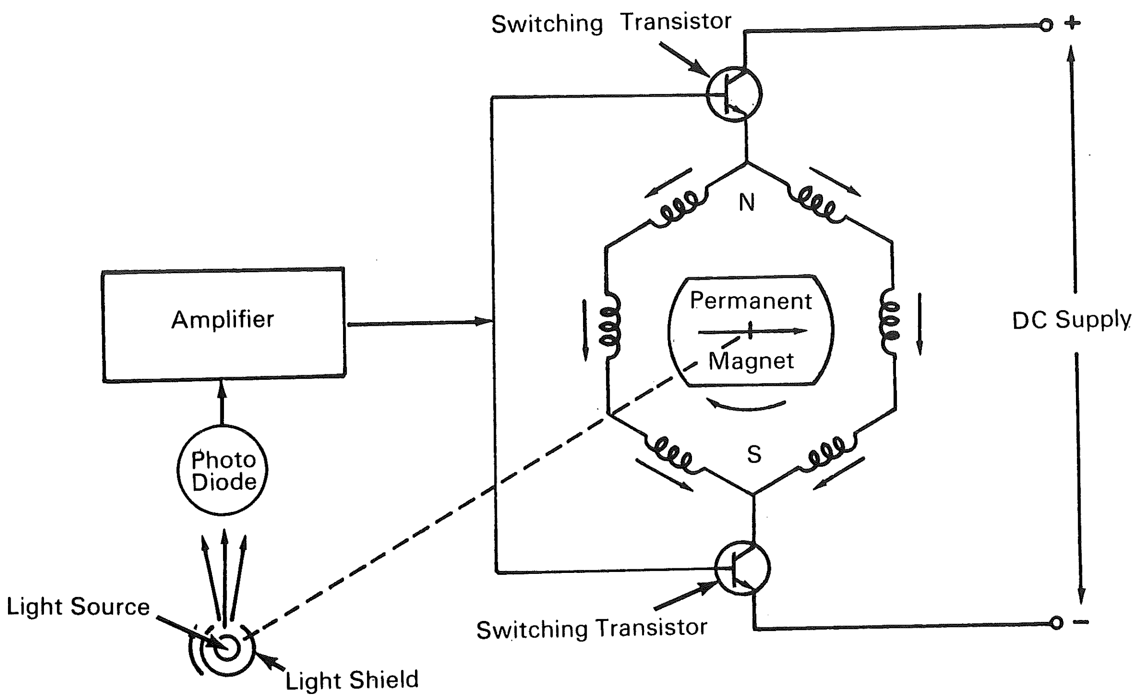
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Cornell Aeronautical Laboratory, Inc.
under contract to
Langley Research Center
(Langley-113)

NASA TECH BRIEF

Brushless DC Motor Has High Efficiency, Long Life



The problem:

Brush life of conventional carbon brush commutators is measured in minutes when operated in a vacuum environment.

The solution:

Development of a brushless dc motor with true dc motor characteristics.

How it's done:

The principle of operation of this brushless motor is identical to that of the conventional dc motor. A torque is produced when two magnetic fields are established with a relative angle between them. This torque reaches a maximum when the relative angle is 90 degrees. It is the function of the commutator to apply the external power to the motor windings in such a manner as to maintain this angle for all positions of the rotating member. Physically, this motor is an inversion of a conventional dc motor in that the rotor is a permanent magnet and the stator is wound (in effect a stationary armature). Attached to the end of the rotor, opposite the drive end, is a small light source within a shield, in which a small aperture has been cut. In the plane of sweep of this aperture are six photodiodes spaced at equidistant points, 60 degrees apart. When the dc supply current is applied, a portion of the light strikes one of the six

(continued overleaf)

photodiodes. The illuminated photodiode produces a current which is amplified and fed to the bases of a pair of switching transistors. These transistors apply the power supply current to the appropriate points in time on the ring-type stator (stationary armature) winding. This produces a magnetic field at the proper angle in relation to rotor position and a turning force is imparted to the rotor. As the rotor turns, the light source, shining through the shield aperture, illuminates the other five photodiodes in turn, and the above process is repeated at each 60 degrees around the solid state commutator. The detecting devices are silicon photodiodes with rise time of 1.5 microseconds and fall time of 15 microseconds, affording a system capable of speeds well in excess of the design speed of 3,000 rpm.

Notes:

1. This motor, because of its excellent response time, has considerable potential for use in the servomechanism field.
2. The motor has an efficiency of 50 percent. This could well be increased to 70 to 80 percent using the latest magnetic alloys and winding techniques.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10355

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

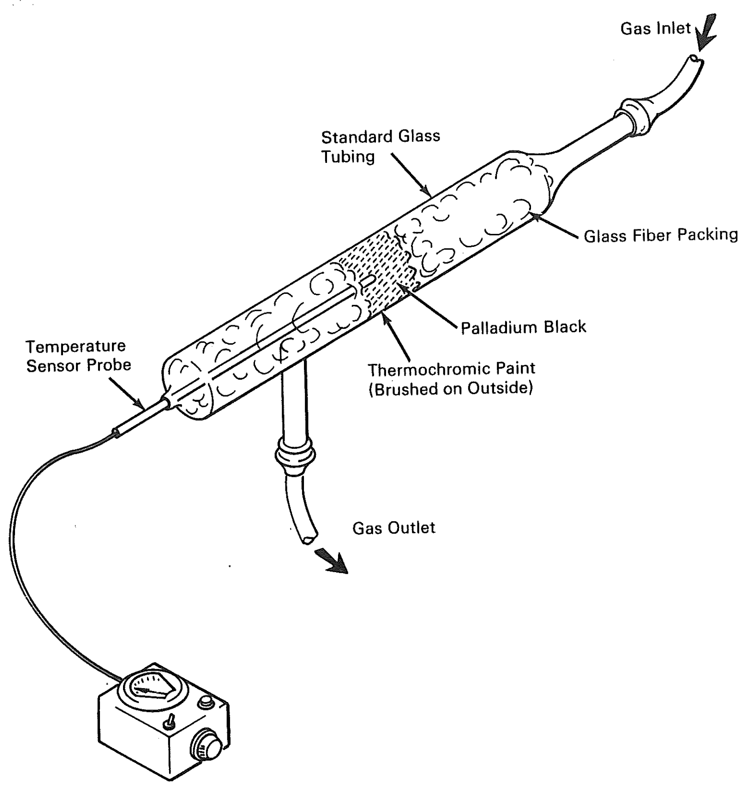
Source: Philip A. Studer
(GSFC-181)

August 1966

Brief 66-10356

NASA TECH BRIEF

"Sniffer" Used as Portable Hydrogen Leak Detector



The problem:

To design a simple, rapid device, preferably portable, for the detection of hydrogen in air, oxygen, nitrogen, or helium. Many modern test facilities use large quantities of hydrogen and a safety hazard would exist if leaks of the highly flammable gas were not closely controlled.

The solution:

A "sniffer" type portable monitor that indicates the presence of hydrogen in contact with activated palladium black by a change in the color of a thermochromic paint, and indicates the quantity of hydrogen present by means of a sensor probe and continuous readout.

(continued overleaf)

How it's done:

The sniffer consists of a short, thin-walled glass or metal tube, packed with 0.5 g of powdered, activated palladium black held in place with compressed glass fibers. The outside of the tube adjacent the palladium black is coated with a thermochromic paint having two successive color change points, at 55° and 85°C. A temperature sensing probe is inserted and sealed into one end of the tube so that it penetrates the mass of the palladium black. The sensor is connected to appropriate instrumentation to give a continuous, direct indication of temperature changes.

In operation, the ambient is drawn through the gas inlet so that it passes through the palladium black. As hydrogen contacts the palladium black, heat is released in direct proportion to the density of the hydrogen. As this temperature passes 55°C, the thermochromic paint changes color to give a visual indication of the presence of hydrogen. Simultaneously, the temperature sensing probe instrumentation registers the change, which, with instrument calibration, can give direct, quantitative data.

Notes:

1. An alternate, more passive method uses a finely woven but porous glass fiber tape or pillow impregnated with palladium black and coated with a pattern of thermochromic paint. Hydrogen entering the porous packet reacts with the palladium black to liberate heat and cause the thermochromic paint to change color.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10356

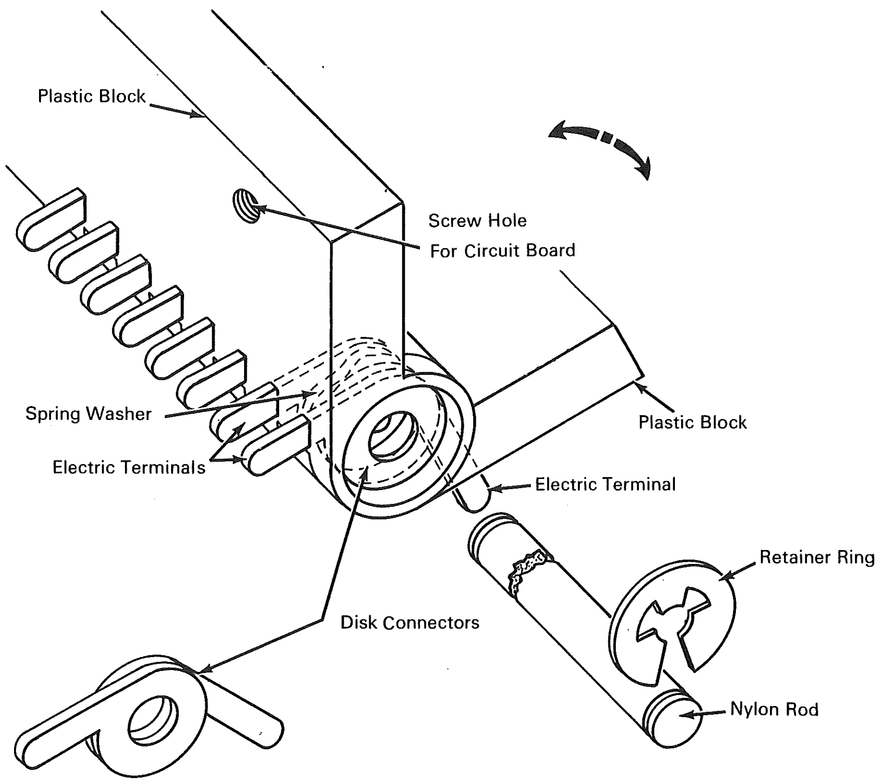
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Marjorie A. Rommel
and Victor H. Dayan
of North American Aviation Inc.
under contract to
Marshall Space Flight Center
(M-FS-846, 806)

NASA TECH BRIEF

Device Serves as Hinge and Electrical Connector for Circuit Boards



The problem:

To design a device that will make both sides of electrical circuit boards readily accessible for component checkout and servicing.

The solution:

A hinge that provides for the mounting of two circuit boards and incorporates connectors which will maintain continuous electrical contact between the components on both boards.

How it's done:

The hinge consists of two plastic blocks with pairs of electrically conductive disks internally spaced along the hinge. Each disk has an arm that serves as an electric terminal, and the two disks in each pair are held in constant contact by spring washers and are arranged so that the arms extend in opposite directions. The hinge block assembly is held together by a single nylon rod with snap-on retainer rings at each

(continued overleaf)

end of the rod. The terminal arms on each hinge block are inserted into corresponding terminal slots on each circuit board. Plastic screws are used to secure the boards to the blocks.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10359

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: P. G. Bethel and G. G. Harris
of Chrysler Corporation
under contract to
Marshall Space Flight Center
(M-FS-743)

August 1966

Brief 66-10361

NASA TECH BRIEF

New Computer System Simplifies Programming of Mathematical Equations

The problem:

To devise a low-cost desk-top computer system that will permit a scientist or engineer with no prior programming knowledge to solve problems in higher mathematics the way he now handles arithmetic problems on a desk-top calculator. The system should also provide the experienced programmer with the flexibility he needs to solve nonroutine problems.

The solution:

An automatic-programming, on-line, multiterminal computer system, called AMTRAN (Automatic Mathematical Translator), which permits a scientist or engineer to enter mathematical equations in their natural mathematical format as they would appear in a textbook and to obtain an immediate graphical display of the solution on an oscilloscope.

How it's done:

The system consists of an operator keyboard, a storage and control keyboard, an oscilloscope, and an electric typewriter. Entry is made in two principal ways: through the keyboards, which provide several hundred of the more common functions and operations of mathematical analysis and through the typewriter, which uses mnemonic labels to provide several thousand less common functions and operations. The system provides the user with graphical and alphameric results as rapidly as the computer can obtain them. A rapid evaluation of intermediate results is afforded by the oscilloscope, with an attached Polaroid camera to provide a permanent record of the final results.

As the equations are entered from the keyboard, the typewriter types out the equations in proper mathematical format. At the end of each mathematical statement, a *carriage return* button is depressed which informs the computer that the mathematical statement has been completed and which causes a carriage return on the typewriter. When the *carriage return* button is depressed, a parenthesis count is made to ensure that parentheses have been properly closed. If such is not the case, the typewriter types out an abbreviated error message. If the user is unfamiliar with the system and wants to know what the abbreviated error message means, he may push an *instructions* button, whereupon the typewriter types out the full error message. In this way, the experienced user does not have to wait for the type-out of the complete error message, while the beginner can call for it if he needs it. The *instructions* button also serves two other functions. At the beginning of operations, pressing the *instructions* button and then any other button provides a type-out giving the purpose of the other button and the rules for using it. The computer system also rejects improper mathematical expressions.

The user may operate in either a "desk calculator" mode or in a "stored program" mode. In the former, the computer executes operations as the user presses the buttons. At the same time, the computer temporarily stores the list of button pushes made by the user. At the end of a mathematical statement, the user may transfer the entire statement to any one of a large number of unassigned blank buttons on the keyboard, making it part of the "stored program" mode. Thus, the user has the option of permanently retaining a pushbutton list of mathematical operations and transforming it into a portion of a stored program. The advantage of the desk calculator mode of operation is that the user can check the work at each step. For operations such as multiple integrations, which require an appreciable time to execute, the operator may elect to operate in the "stored program" mode.

(continued overleaf)

In this instance, a lighted *execute* button is pushed, causing the light to go out and suppressing execution. Then a list of button pushes (and mnemonic code type-ins) is entered without executing the associated operations. When the *carriage return* button is depressed at the end of the mathematical statement, the pushbutton list is terminated. The pushbutton list can then be assigned to a blank pushbutton or mnemonic call code as previously described, after which execution is restored. Complete programs are developed by embedding equations or sets of equations into a single pushbutton list. An entire program which may run for hours is then set into motion when a single button is pushed.

The AMTRAN system operates at three levels. First, it contains a real-time FORTRAN IV interpreter which permits the user to type in, execute, and debug FORTRAN programs on line. The user, if he wishes, may then automatically punch a FORTRAN source deck and process it in the conventional manner. The second level provides tightly programmed operators for numerical analysis, and the third level provides a large number of "convenience" operators for classical analysis. The highest level at which the AMTRAN system may operate depends on the computer with which it is used.

Notes:

1. The AMTRAN system lends itself exceedingly well to multistation, time-sharing operation.
2. The system described was developed for use with the IBM 1620 and Univac 1107 computers, but is adaptable to other computer systems as well.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10361

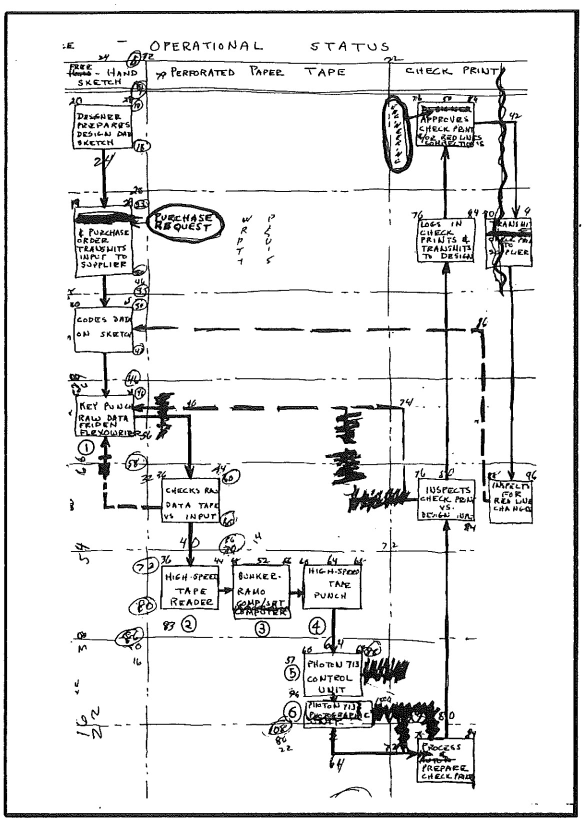
Patent status:

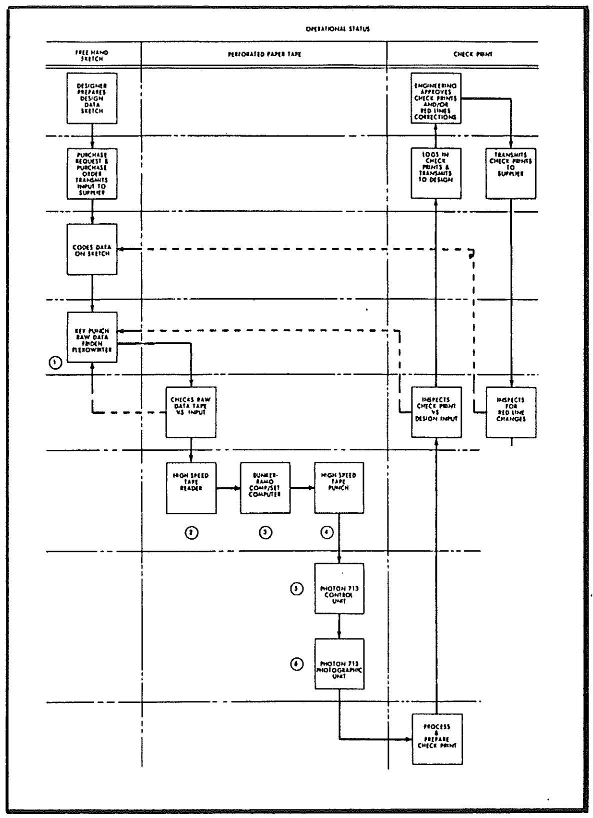
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Robert N. Seitz
Juris Reinfelds, and Lawrence H. Wood
(M-FS-441)

NASA TECH BRIEF

Automated Drafting System Uses Computer Techniques





The problem:

In implementing hardware production involving numerous complex items, large numbers of schematic and block diagrams must be produced from the design engineers' freehand sketches. Depending on complexity, a draftsman spends an average of 12 to 15 hours in producing a finished diagram. A system is needed that will eliminate this excessive time that produces no essentially "new" information.

The solution:

An automated drafting system that codes conventional drafting symbols and their coordinate locations on standard size drawings for entry on tapes that are used to drive a high speed photocomposition machine.

How it's done:

The designer's freehand sketch is marked with an alphameric code that translates the symbols, connect-

(continued overleaf)

ing lines, and coordinate locations into machine language. The coded data is converted into a raw data tape and typewritten text that can be checked for errors against the coded sketch. The raw data tape is fed to a computer that is programed to translate, arrange, and expand the raw data for transfer to a high speed output tape-perforating punch. The high speed punch converts computer impulses into holes in a paper tape that is fed into the control unit of a high speed photocomposition unit that responds to the pulsed instructions by photographically reproducing the diagram line by line and symbol by symbol in their prescribed coordinate locations.

Notes:

1. With this system, complex diagrams require only 3 to 4 hours including approximately 3 hours for translating the sketch information into machine language.
2. In one program, approximately 6,600 "D" size drawings will be automatically produced by this system at an estimated savings in excess of $140,000.00.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10362

Patent status:

No patent action is contemplated by NASA.

Source: Donald H. Millenson
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-788)

NASA TECH BRIEF

Infrared Television Used to Detect Hydrogen Fires

The problem:

Modern test facilities have occasion to use large quantities of hydrogen gas from time to time. Because hydrogen is highly flammable and because hydrogen–air and hydrogen–oxygen flames are relatively imperceptible to the human eye, a device or system is needed that will make both the fire and its point of origin clearly visible to the naked eye.

The solution:

A closed circuit television that sees in the infrared and displays on a standard cathode ray monitor screen.

How it's done:

A standard, commercially available closed circuit television system is used to detect the hydrogen fires. The television camera vidicon tube is replaced by one with spectral response out to the near infrared area to approximately a 2.1 micron wavelength. Infrared bandpass filters are placed in front of the camera lens. These filters provide good contrast between and definition of hydrogen fires and the background and lighting conditions normally found in test areas.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10363

Patent status:

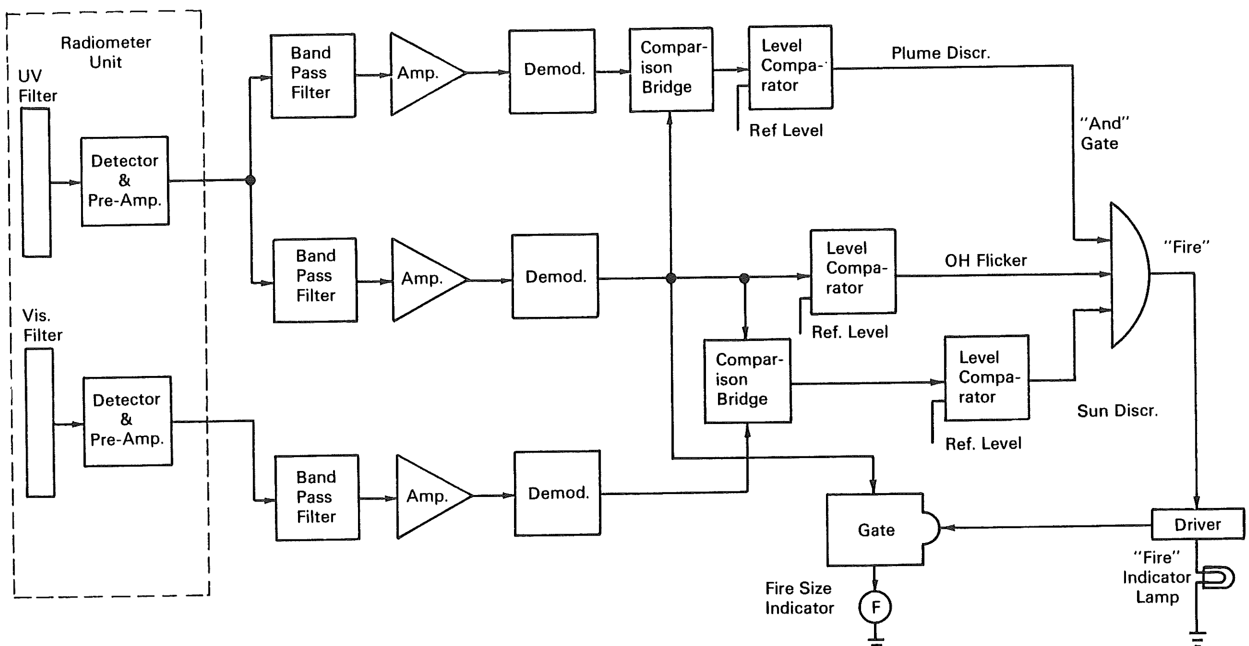
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Robert T. Proffitt
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-654)

Category 01

NASA TECH BRIEF

Hydrogen Fire Detection System Features Sharp Discrimination



The problem:

To design a system that will detect hydrogen fires quickly and with high reliability plus freedom from false alarms.

The solution:

A system that detects the flickering ultraviolet (UV) radiation emitted by the OH molecule, a short-lived intermediate combustion product found in hydrogen–air flames. In a space application, the system discriminates against false signals from sunlight and rocket engine exhaust plume radiation.

How it's done:

The system consists of a radiometer unit and signal processing circuitry. The radiometer unit contains quartz entrance optics, UV and visible filters, and UV and visible detectors with their preamplifiers. The signal processing circuitry is made up of three major logic subsystems: an OH flicker detector, a sun discriminator, and a rocket engine exhaust plume discriminator. The OH flicker detector circuit registers "true" only when viewing radiation flickering at appropriate frequencies, i.e., in the spectral region of OH UV emission from 2600 to 3200 angstroms.

(continued overleaf)

Unmodulated sunlight is rejected by the OH flicker detector circuit. Rejection of the exhaust plume radiation is made by comparison of intensities in two temporal (frequency) regions at a single spectral point. The signal levels at the two frequencies are compared by a bridge and the plume discrimination circuit indicates a "false" signal for incident plume radiation.

Signals from the three signal processing circuits are applied to the "And" gate, which indicates "fire" only when all three subsystems give a "true" signal. A "fire" signal gates the fire size indicator whose output is proportional to the intensity of the modulated OH radiation.

Notes:

1. Although developed primarily for use in space hardware, this detection system could find use wherever hydrogen is manufactured, used, or stored.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10368

Patent status:

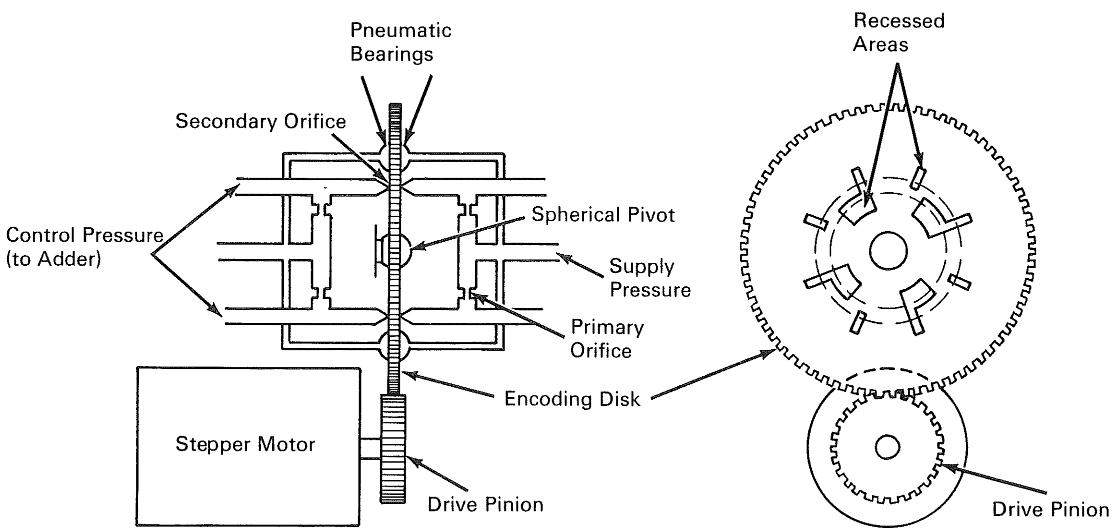
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Clark S. Bright
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center

(M-FS-643)

NASA TECH BRIEF

Pneumatic Binary Encoder Replaces Multiple Solenoid System



The problem:

An encoder is required as the pilot stage of a digital actuator. Multiple solenoid systems have been used in the past but they involve much cabling and relatively high power consumption.

The solution:

A pneumatic binary encoder that operates in a flip-flop manner to valve pressurized gas at either a high pressure (600 psi) or low pressure (200 psi).

How it's done:

The pneumatic encoder consists of a stepper motor, encoding disk, and sets of primary and secondary orifices. The encoding disk is mounted on a spherical pivot and rotates between pneumatic bearings to keep frictional torques to a minimum. A stepper motor drives the encoding disk and responds to electrical input pulses to rotate its output shaft through a predetermined angular displacement, e.g. 7.5°, 15°, or 90°, for each pulse received. Rotation of the encoding disk by degrees per input pulse is controlled by selection of drive pinion-to-encoding disk gear ratio. The surface of the encoding disk is recessed in certain areas so that, as the disk is rotated, the secondary orifices are either vented or capped off depending on the angular positions of the recessed areas.

In operation, a supply of gas under pressure is fed to a manifold, on either side of the encoding disk, through sets of primary orifices to sets of secondary orifices that touch the normal suface of the disk as it rotates. In contact with the disk surface, pressure within the secondary orifices holds at its high pressure level of 600 psi. As the disk is rotated by the stepper

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motor to a position that indexes a given secondary orifice with a recessed area in the face of the disk, pressure in that orifice drops to its low value of 200 psi. Thus, the flip-flop characteristic of the system is fed in binary form to the adders in accordance with the pulses driving the stepper motor.

Notes:

1. Selection of the proper pinion-to-disk gear ratio provides a large number of discrete angular disk positions so that 6 to 8 adder circuits can be operated from a single disk.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10374

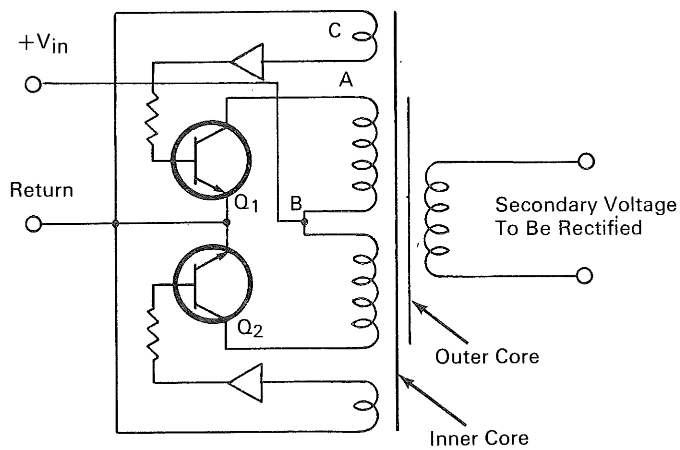
Patent status:

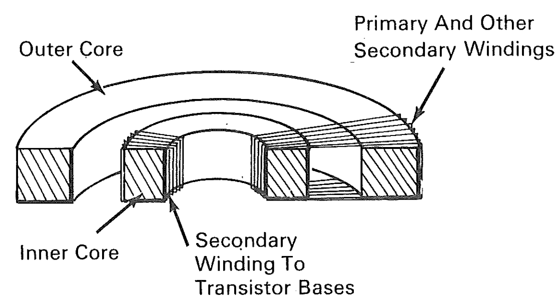
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Weston Hydraulics, Limited
under contract to
Marshall Space Flight Center
(M-FS-665)

NASA TECH BRIEF

Efficient DC to DC Converter Eliminates Large Stray Magnetic Fields





The problem:

To design a dc to dc converter that provides high switching efficiency and does not produce large stray magnetic fields. As the core switches in conventional converters, the difference between the current available and the load current referred to the primary is used as a magnetizing current. This operation wastes power and produces large ac magnetic fields which can interfere with nearby circuits.

The solution:

A two-core nonsaturating converter that uses one core to provide positive feedback and the combination of the two cores for the transformer.

How it's done:

In order to avoid excessive waste of power and generation of stray magnetic fields, a core must be switched before it saturates. This converter accomplishes this action by using two concentric cores with the same number of magnetizing turns so that the inner core will saturate before the outer core. The inner core provides the positive feedback for switching. To assure that the magnetizing current is the same for both cores, the current in the feedback winding must be negligible. A high input impedance amplifier is therefore used to amplify the feedback signal. If Q_1 is on, there will be a positive voltage applied from B to A and the induced voltage at C will keep Q_1 on. As the inner core saturates before the outer core, the voltage at C collapses and Q_1 turns off. The flux in the inner core begins to change in the other direction, turning Q_2 on. Q_2 will be on until the inner core saturates in the other direction.

After the inner core saturates, the rate of change of magnetizing current does not increase greatly because the flux in the outer unsaturated core can still increase substantially before the latter core saturates. Because the rate of change of magnetizing current has not increased greatly, the transistor will turn off right after saturation of the inner core and switching will occur.

(continued overleaf)

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10376

Patent status:

No patent action is contemplated by NASA.

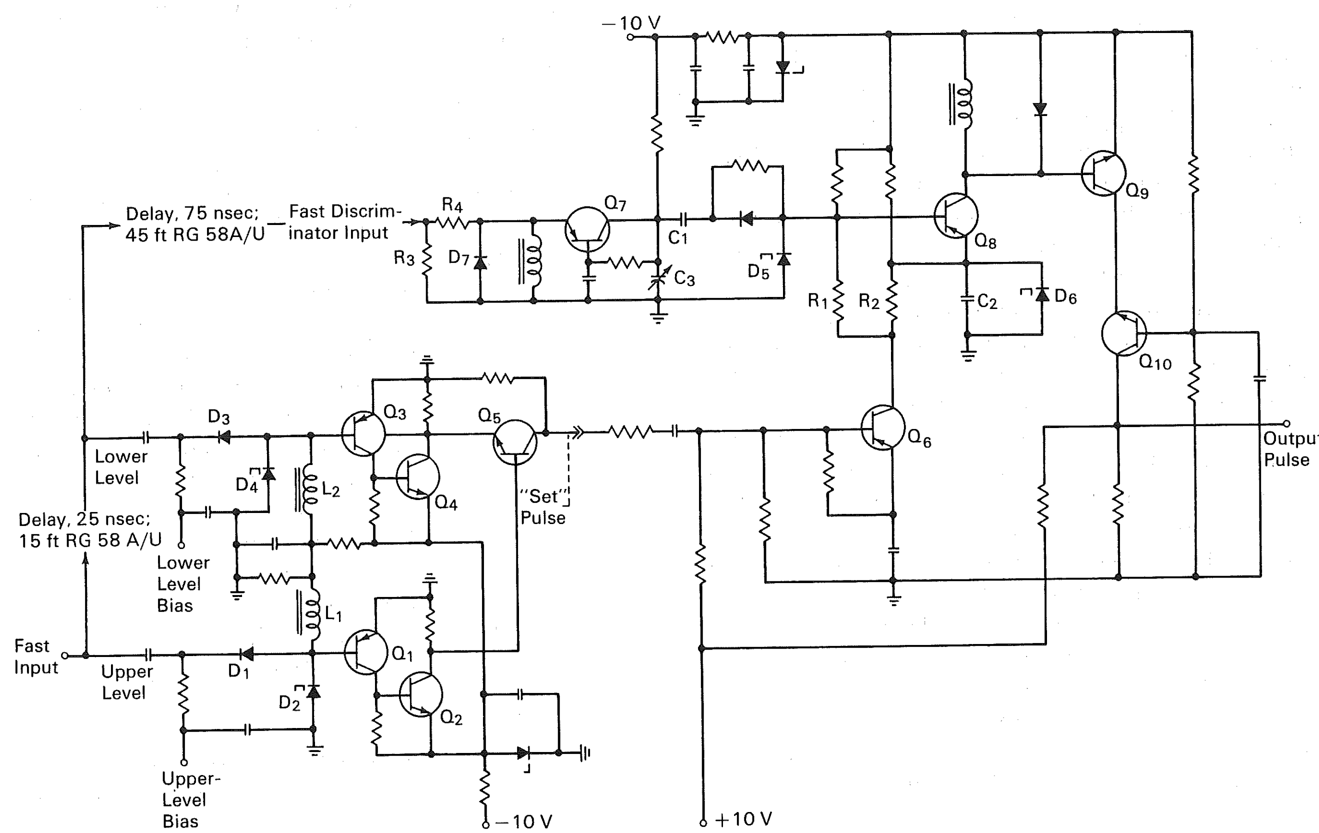
Source: Edwin O. Tums
of Enrico Fermi Institute
for Nuclear Studies,
The University of Chicago
under contract to
Goddard Space Flight Center
(GSFC-463)

August 1966

Brief 66-10377

NASA TECH BRIEF

Single Channel Pulse-Height Analyzer Operates in Subnanosecond Range



SINGLE-CHANNEL PULSE-HEIGHT SELECTOR BOARD

FAST-DISCRIMINATOR BOARD

The problem:

To accurately measure nuclear state lifetimes shorter than 1 nanosecond. Detected particles do not commonly produce monoenergetic pulses but rather a whole spectrum of random pulse amplitudes. Because of this, the time response of a discriminator displays "time walk" as pulses of differing amplitude reaching the discriminator trigger threshold at slightly different times after their initiation. A second cause of timing error, "time jitter" is caused because a fraction of the pulses arrive at the discriminator while it is still subsiding from preceding pulses.

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The solution:

A single channel pulse-height analyzer that can handle approximately 10^4 random pulses per second above the lower discriminator level with negligible output pulse loss. By reversing the customary logic arrangement, "time-walk" is reduced and "time-jitter" is all but eliminated.

How it's done:

Input pulses are selected by the single channel pulse-height selector consisting of upper- and lower-level tunnel diode univibrator discriminators and an anticoincidence circuit. The upper-level discriminator consists of D_1, D_2, L_1, and transistors Q_1 and Q_2, and the lower-level discriminator consists of D_3, D_4, L_2, and transistors Q_3 and Q_4. The upper- and the lower-level biases allow for discrimination of the fast input pulse. Transistor Q_5 is the anticoincidence element. Producing single channel selector action involves the application of the output of the lower-level discriminator to the emitter of Q_5 and the connection of the output of the upper-level discriminator to its base. In the absence of an upper-level discriminator pulse, Q_5 acts as a common base amplifier and produces a "set" pulse at its collector. If an upper-level discriminator pulse does exist, Q_5 is cut off and no "set" pulse is produced. In order to ensure anticoincidence action, the upper-level discriminator pulse is approximately 200 nanoseconds long and precedes the lower-level pulse, which is 125 nanoseconds long, by approximately 25 nanoseconds. The delay is produced by the insertion of 15 feet of RG 58A/U coaxial cable between the upper- and lower-discriminator inputs. The output ("set" pulse) of the anticoincidence circuit is shaped in transistor Q_6 and produces a short, positive pulse at its collector. This pulse places D_5 and D_6 in their low-voltage state due to current flow in R_1 and R_2.

The fast input signal, which is delayed a total of 100 nanoseconds, is terminated at the emitter of Q_7 by the parallel-series combination of D_7, R_3, and R_4. This delay is introduced to ensure that electrical quiescence exists in the fast-discriminator circuit after it has received a "set" pulse. The limited pulse produced at the collector of Q_7 is differentiated in C_1, and the resultant current pulse switches D_5 to its on state. The on voltage of D_5 causes Q_8 to conduct strongly until C_2 reaches the D_6 firing voltage, at which time Q_8 ceases to conduct. Any further pulse presented to D_5 before another "set" pulse has been received, cannot develop sufficient voltage in D_5, because of its high conductance in the on state, to cause further conduction in Q_8. The pulse produced at the collector of Q_8 is amplified and limited in Q_9 and Q_{10} and produces a quite uniformly shaped 5-volt negative pulse, the leading edge of which is well related in time to the fast input signal.

Notes:

1. To produce the best possible timing, variable capacitor C_3 is adjusted until the fast-discriminator inputs, as observed with a fast oscilloscope gated by the accompanying analyzer outputs, show the least "time walk".
2. This fast single channel pulse-height analyzer, mounted on two 2 1/2- by 3-inch circuit boards, is extremely stable and replaces a considerable amount of electrical circuitry previously used for this function, while providing excellent timing capability.
3. Further information concerning this innovation is presented in NASA TN D-2673, "Subnanosecond Time Resolution Single-Channel Pulse-Height Analyzer" by Theodore E. Fessler and William K. Roberts, February 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; price $1.00. Inquiries may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10377

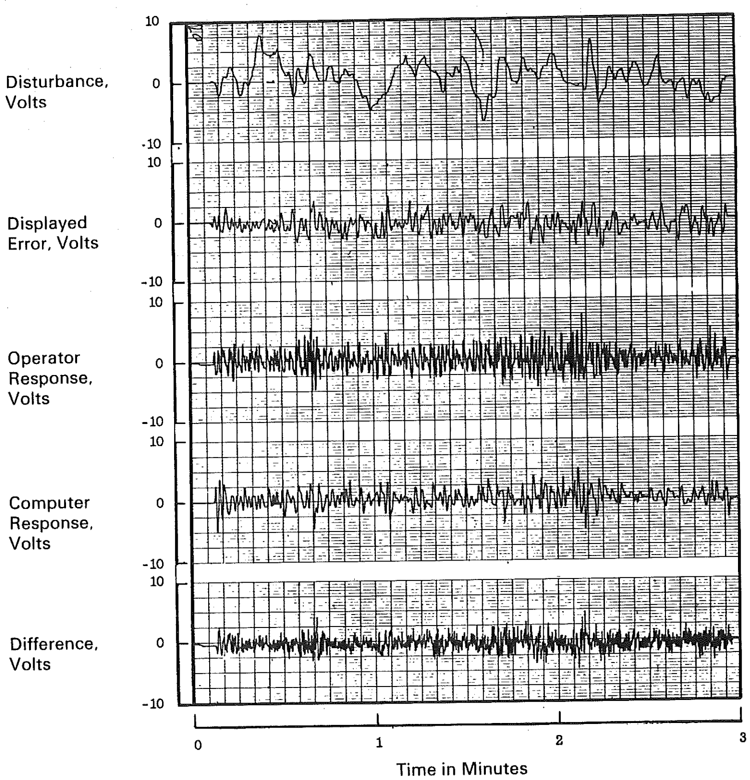
Patent status:

No patent action is contemplated by NASA.

Source: (Lewis-267)

NASA TECH BRIEF

Human Transfer Functions Used to Predict System Performance Parameters



The problem:

In the design of complex and expensive mechanical or electromechanical systems, it is desirable to gain a quantitative understanding of the system prior to construction of hardware. Operator opinion, based upon trial of prototype systems, leaves much to be desired, especially in systems that will be operated by numerous personnel.

The solution:

An applications technique that employs transfer functions that represent the input–output relation for a human operator when controlling a compensatory, closed-loop system. An automatic, parameter-tracking, model-matching method compares the transfer functions of a human operator with the output of an analog computer model of the human operator that

(continued overleaf)

is fed the same inputs that the human operator reacts to.

How it's done:

In this application, the human operator and the computer are fed identical disturbance signals plus feedback related to system response. An oscilloscope display conveys the signals to the human operator by moving a display line or lines away from a reference line or lines a distance related to the amplitude of the error between disturbance and system response. The human operator reacts to keep the displayed signal aligned with a fixed reference on the display by moving a control stick similar to that used to manuever conventional aircraft. The difference between disturbance and system response may be in one or two axes and appears as linear or nonlinear variations from normal, changing with time. An oscillograph is used to plot, as functions of time, (1) the disturbance signal, (2) the displayed error (difference between disturbance and system response), (3) operator response, (4) computer model response, and (5) difference between operator response and computer model response.

Notes:

1. This technique provides the means to make analytical studies of a wide variety of manually controlled systems.
2. This system could be used to train previously unused muscles for artificial arm operation.
3. The technique could be a valuable tool in gravity control training of hemiplegics.
4. Human operators are adaptive, and the same transfer function will not apply for all mechanical systems and displays. Measurements of the variations in human transfer functions have been made and are reported in the publications listed in Note 5.
5. Further information concerning this innovation is presented in NASA TN D-1952, "Measured Variation in the Transfer Function of a Human Pilot in Single-Axis Tasks" by James J. Adams and Hugh P. Bergeron, October 1963; NASA TN D-2177, "Measured Transfer Functions of Pilots During Two-Axis Tasks with Motion" by Hugh P. Bergeron and James J. Adams, March 1964; NASA TN D-2394, "Measurements of Human Transfer Function with Various Model Forms" by James J. Adams and Hugh P. Bergeron, August 1964; and NASA TN D-2569, "Measured Human Transfer Functions in Simulated Single-Degree-of-Freedom Nonlinear Control Systems" by Hugh P. Bergeron, Joseph K. Kincaid, and James J. Adams, January 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Inquiries may also be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10379

Patent status:

No patent action is contemplated by NASA.

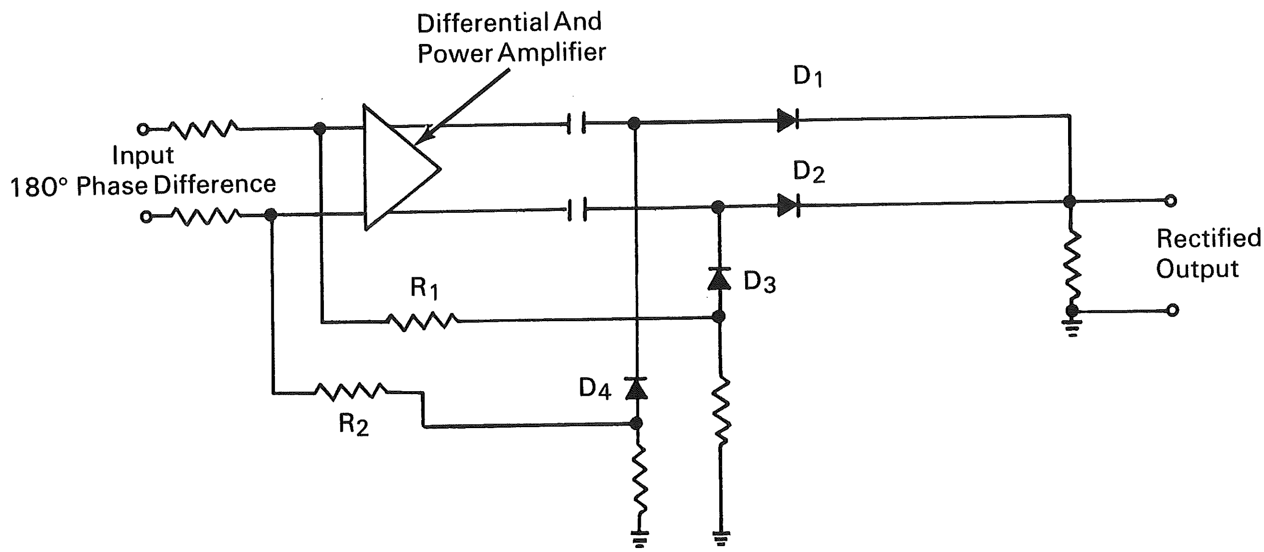
Source: Langley-203

August 1966

Brief 66-10382

NASA TECH BRIEF

Feedback Loop Compensates for Rectifier Nonlinearity



The problem:

To compensate for the nonlinear impedance of the rectifiers in a signal processing circuit. This circuit is required to rectify two sinusodial signals which are 180° out of phase and produce a single full-wave rectified output signal.

The solution:

Provide two negative feedback loops each of which incorporates a feedback rectifier to compensate for the nonlinearity of the signal processing circuit.

How it's done:

In the original circuit, the out-of-phase input signals are applied to a differential amplifier and a power amplifier. The amplified signals are rectified by D_1 and D_2 to produce a full-wave rectified output. The negative feedback loops consist of D_3 and R_1 and D_4 and R_2, respectively, between the two input branches.

When the positive portion of one signal is being passed by one of the rectifiers (D_1 or D_2), the negative portion of the other signal is being passed by a compensating rectifier (D_3 or D_4) to the amplifier input. Thus as the positive signal feeds into one rectifier, the negative signal on the other line passes through the compensating rectifier and is fed back into the positive input of the amplifier. Initially, this signal is small so that the effective feedback voltage is correspondingly small, and essentially full gain of the input signal is achieved. When the input signal increases so that the rectifiers are operating in the linear region, the feedback signal increases so as to cut down the input signal.

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The characteristics of the paired rectifiers (D_1, D_3 and D_2, D_4) must be closely matched to provide for maximum linearity between the input and output signals.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10382

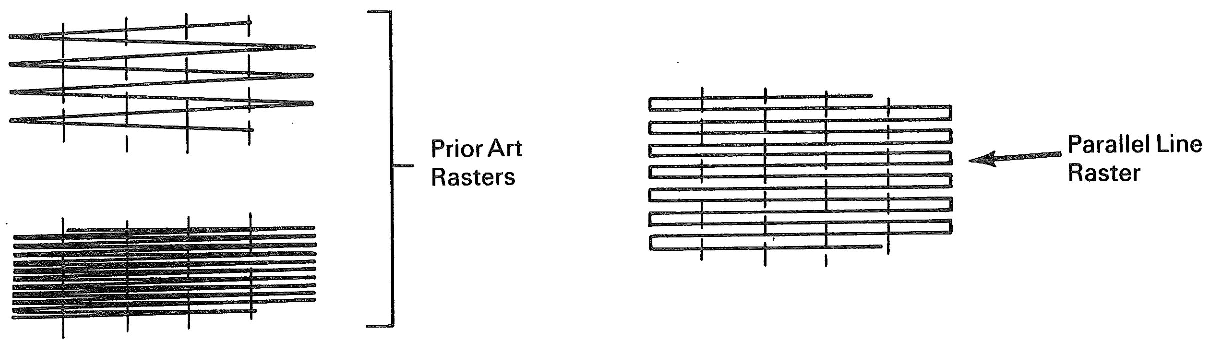
Patent status:

No patent action is contemplated by NASA.

Source: Sperry Gyroscope Company
under contract to
Marshall Space Flight Center
(M-FS-384)

NASA TECH BRIEF

Parallel Line Raster Eliminates Ambiguities in Reading Timing of Pulses Less Than 500 μsec Apart



The problem:

The precision timing of events occurring less than 500 μsec apart for observation of hypervelocity phenomena. In prior art, sawtooth, marker, and triangle voltages were combined to provide ramp-type rasters where vertical responses tended to go together and were indistinguishable as to time separation.

The solution:

Generate a raster consisting of parallel horizontal lines instead of a triangular sweep.

How it's done:

A staircase waveform is generated by a blocking oscillator that is driven by a signal derived from the same crystal oscillator that drives the marker generator. Since the rise time of the staircase voltage is less than 50 nanoseconds, no appreciable "turn around time" error is introduced (provided the oscilloscope has a bandwidth of 10 megacycles or more). The parallel line raster uses a staircase vertical deflection instead of a ramp and eliminates the ambiguities in reading timing of pulses close to the end of each line.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10386

Patent status:

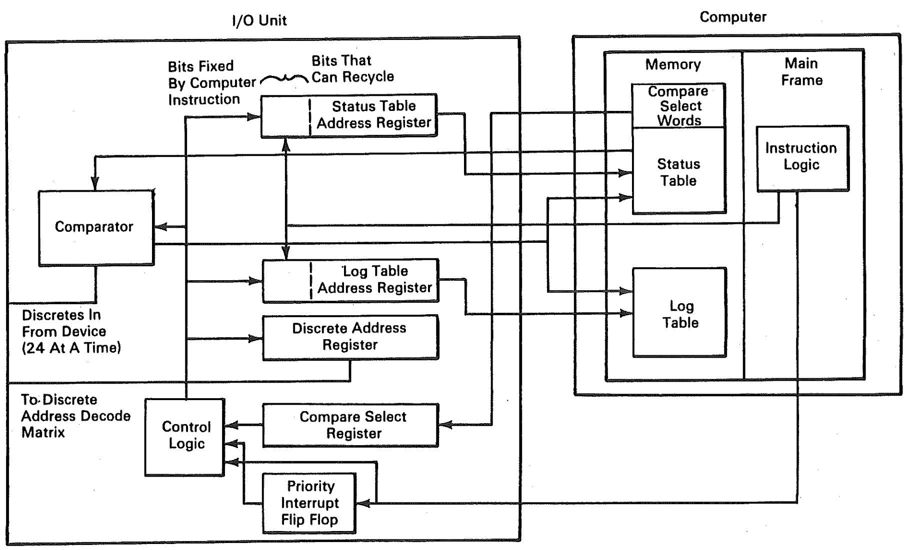
No patent action is contemplated by NASA.

Source: Arthur P. Horne
(JPL-805)

Category 01

NASA TECH BRIEF

System Monitors Discrete Computer Inputs



The problem:

A large automated checkout system often has a few thousand discrete input lines that require monitoring. The monitoring system must be capable of logging enough current information about the changes so that their history can be reconstructed. Checkout conditions often require the system to recognize the discrete changes. In such cases, a discrete input change must be capable of interrupting the program that the computer main frame is performing in order to take action to service the device being checked. The monitoring and logging must not usurp the computer processing function or memory accesses.

The solution:

The discrete lines are scanned often enough to keep the stored data current. On every scan the present condition of each line is compared with the data already in the Status Table from a previous scan. When a difference is detected, the Status Table is updated. At the same time, the new status, time of compare, and discrete addresses are stored in the Log Table in the computer memory. The I/O (Input/Output) Unit, by virtue of bits stored in the Compare Select Register, will sense which discretes are selected to be monitored.

When special action is required as a result of a change in the selected discrete lines, a Priority Interrupt will be actuated. This actuation will cause the computer to interrupt the program it is performing and jump to a predesignated program whenever a noncompare is found on selected discrete lines.

The computer main frame and memory must be available for other functions. The comparing, addressing, and controlling are therefore performed in logic blocks within the I/O Unit. A single instruction starts the unit processing. Memory accesses are done on a priority basis. Since the discrete data rate of change is slow, the scanning rate (maximum,

(continued overleaf)

limited by memory access rate) need not be at the maximum memory access rate. The availability of accesses for each I/O is determined on a memory access priority basis. The Discrete I/O Unit is assigned the lowest priority. It uses only the memory accesses not being used by other computer functions.

The Log Table length is optionally determined by the computer instruction. When the selected table length is half filled or filled, the computer can be interrupted and be caused to jump to a preselected routine.

How it's done:

A Status Table and a Log Table in the computer memory are used to store data. A table, made up of 63 sequential memory locations, is used to form the Status Table for 1512 discretes. The computer has a 24-bit word. Each bit of the 63 words indicates the status of a discrete. The first word of the table contains the status of discretes 1–24, the second contains discretes 25–48, and so on through the 63 words. This table is updated when the input lines change as the discretes are scanned. The addresses of these memory locations are held in the Status Table Address Register in the I/O Unit. This Address Register is stepped an increment by the Control Logic when the next discrete status is needed. The contents of these addresses of the Status Table in the computer memory are shifted into the Comparator, after which the 24 input discrete lines are gated into the Comparator for the comparison. When the bits from the table and input discretes do not compare, the Log Table is used for storing the information needed to reconstruct the discrete history. Two sequential Log Table locations are used to store this data. The first location contains the present state of the 24 discretes in a single word. The second location contains the 18-bit count of a relative timer and the number of the discrete word (which of 63). The relative time counter used here is a 27-bit counter triggered by a 1-millisecond pulse. Whenever the 19th bit position overflows, 27 bits are stored in the Log Table using 2 sequential Log Table locations.

So that discrete input lines can be selected for monitoring, the 3 words preceding the Status Table are used. The first 63 bits in these words are used to indicate which of the 63 discrete words in the Status Table are selected for comparison with the discrete inputs. In the first word of the 3 words, bit 0 is associated with the first discrete word in the Status Table which holds the status of the first 24 discretes. Bit 'one' of the first word of the three words is associated with the second word which holds the status of the second 24 discretes and so on through 63 bits. A 'one' in any of the 63 bit locations causes the Status Table to be updated and the Log Table to be used when there is a noncompare between that Status Table word and the associated discrete inputs. These bits can be set or reset at any time in order to select or reject discretes for monitoring. These 63 bits are transferred to the Compare Select Register in the I/O Unit for testing by the Control Logic.

A Priority Interrupt flip-flop in the I/O Unit is set by the initial command from the computer. This flip-flop is set when it is desired to have the computer interrupt the program it is performing and jump to a predesignated one when there is a noncompare between the Status Table and input discretes selected for comparison. This condition is required when the device must be serviced after an Input Discrete has changed.

Two separate registers in the I/O Unit hold the computer memory addresses of the Status and Log Tables. The most significant bits of the Log and Status Table Address Registers are set by a single computer instruction. These bits determine the starting addresses of the tables in the computer memory. The least significant bits of the registers start out reset and are counted up as the addresses are used. The quantity of the least significant bits determines the table lengths. The Log Table length can be selected by computer instruction to be 512, 1024, or 2048 words long. Normally, the I/O Unit activity can be terminated by computer instruction at the time this table is half full or full during a program interrupt. The Status Table length is selected by jumper wiring on a terminal board. This is feasible because the number of discretes are usually fixed in a system. Both Address Registers recycle when the length that was selected is filled.

The program interrupt and memory access priority systems are part of the computer main frame capability. Two command words are used to initiate the I/O Unit. These words set the Table Addresses, Log Table length and type of monitoring.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10389

Patent status:

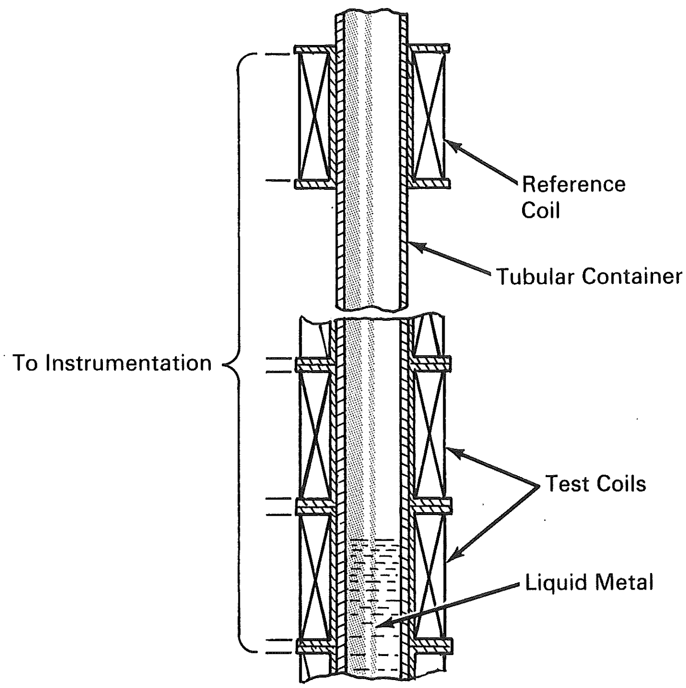
No patent action is contemplated by NASA.

Source: J. J. Burns
of Radio Corporation of America
under contract to
Marshall Space Flight Center
(M-FS-1021)

August 1966 Brief 66-10392

NASA TECH BRIEF

Inductive System Detects Level of Conducting Fluids



The problem:

To monitor the liquid level of a conductive fluid that is at a high temperature in a fully closed opaque container. It is required that no penetration of the container be made and that no extraneous matter, float, or plug be inserted.

The solution:

A system that takes advantage of the self-inductance characteristic of a solenoid with respect to the fluid material inserted into its core.

How it's done:

Axially aligned coils surround a tubular container that is partially filled with liquid metal at an elevated temperature (approximately 700°F). The amount of liquid metal in the tubular space within a given coil determines the self-inductance of that coil. A reference coil, having a constant self-inductance, is used to compare the self-inductances of the test coils. An automatic stepper switch connects each coil in succession to a bridge circuit for comparison with the reference coil. A series of lights and meters indicates the liquid level in the container since each meter represents a specific segment of the container column and each energized light represents a filled segment. A separate meter is used to indicate, in terms of a scale reading, the exact location of the fluid surface in the

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uppermost segment containing, but not filled with, the liquid metal.

Notes:

1. This system was used successfully in a two-phase mercury loop and would be useful in any high-temperature liquid-metal system.
2. The system shows fast response time and is relatively insensitive to temperature fluctuations.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10392

Patent status:

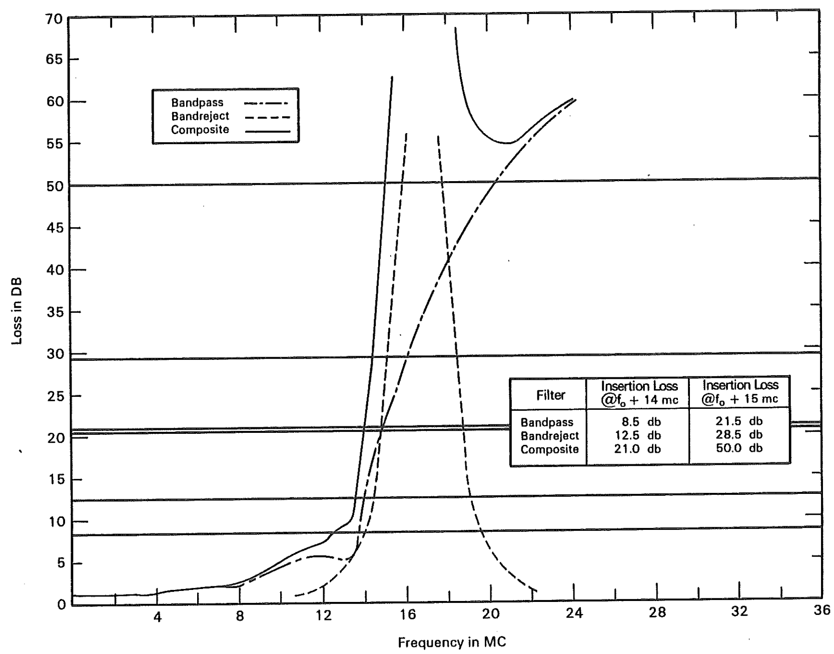
This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: Paul W. Roeske et al
(Lewis-322)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Composite Filter Steepens Rejection Slopes in Microwave Application



Filter	Insertion Loss @f_o + 14 mc	Insertion Loss @f_o + 15 mc
Bandpass	8.5 db	21.5 db
Bandreject	12.5 db	28.5 db
Composite	21.0 db	50.0 db

The problem:

To obtain sharp rejection slopes in microwave transmission by filtering techniques. Common monotonic rejecting filters, when used to yield bandpass or bandreject responses, contain complex arrangements of circuit elements which cannot be readily realized as a microwave structure.

The solution:

A composite filter consisting of a bandpass filter to shape the passband and a bandreject filter on each edge of the bandpass filter to steepen the rejection slopes.

How it's done:

High unloaded Q-filters are used in order to prevent interaction between the bandpass and bandreject filters that could result in spurious transmissions. As the table and graph show, the bandpass filter (tuned at f_0) exhibits certain insertion losses at f_0+14 mc and at f_0+15 mc. The bandreject filter (tuned at $f_0+16.75$ mc) exhibits sharper insertion losses at f_0+14 mc and f_0+15 mc, while the composite filter insertion loss is seen to be the algebraic sum of the bandpass and bandreject losses.

Notes:

1. A typical Butterworth design would require 40 resonant cavities with unloaded Q's of 47,000, unattainable in standard waveguide designs. The composite design would contain only 27 cavities with unloaded Q values in the order of 8,000.

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2. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10393

Patent status:
No patent action is contemplated by NASA.

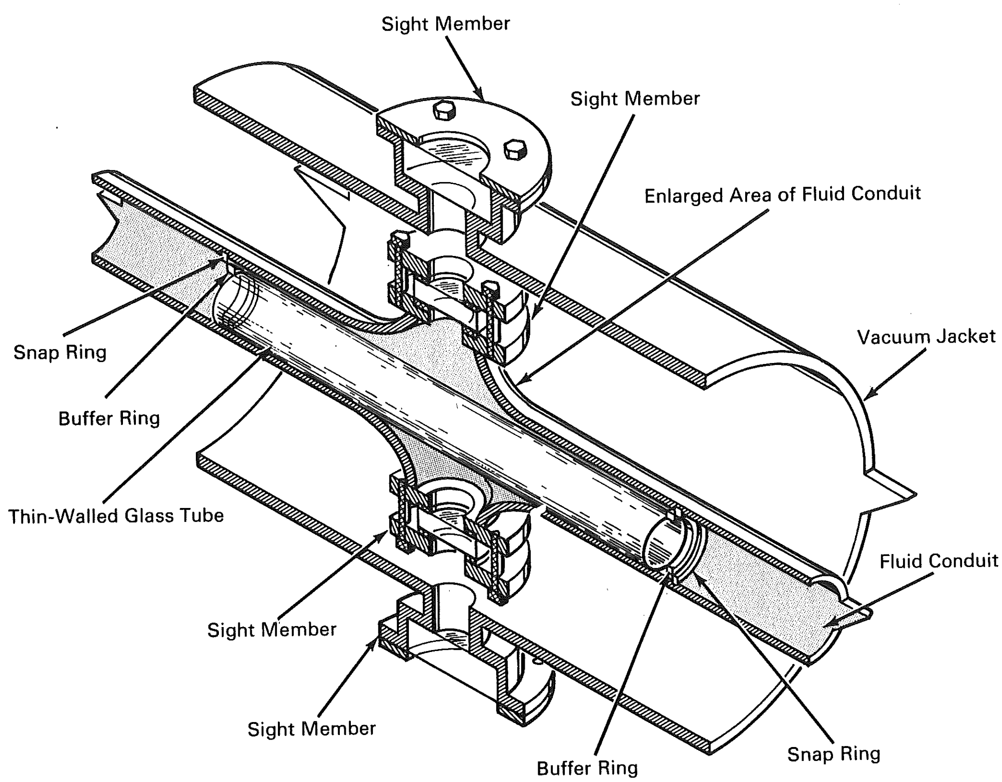
Source: Dorne and Margolin, Inc.
under contract to
Goddard Space Flight Center
(GSFC-480)

August 1966 Brief 66-10394

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

High Pressure Cryogenic Liquid Flow Sight Assembly Provides Streamlined Flow for Easy Observation



The problem:

To observe cryogenic liquids flowing through a smooth pipe at pressures up to several hundred pounds per square inch. Previous methods usually necessitated bonding a section of glass pipe into the metal piping; a difficult and expensive operation because of differences in the coefficient of expansion of metal and glass under cryogenic conditions. Also, the glass pipe must necessarily have an extremely heavy wall thickness to contain the pressures involved.

The solution:

A high-pressure cryogenic observation window assembly which houses a thin wall glass pipe held within a steel retainer.

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How it's done:

A thin wall glass cylinder is mounted within the T-joint assembly and connected into the metal piping to provide a continuous smooth flow path. Breakage of the sight tubing is eliminated by providing controlled leakage paths around the ends to equalize the interior and exterior pressure and to provide a streamlined fluid flow path which eliminates eddying and turbulence of the fluid. An observation window is also mounted in the T-joint assembly by a pressure seal with a lead gasket bearing on a serrated metal flange and held in compression by a bolt and nut arrangement. The T-joint observation window assembly is of high pressure construction and designed to contain the high pressure fluid surrounding the glass tubing. Since the hardware is exposed to cryogenic temperatures, this entire T-joint assembly is enclosed in an insulating vacuum environment by encapsulation in a second, more conventional, sight assembly unit.

Notes:

1. The sight assembly which consists of relatively inexpensive components can accommodate fluids under wide range of pressures and temperatures.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10394

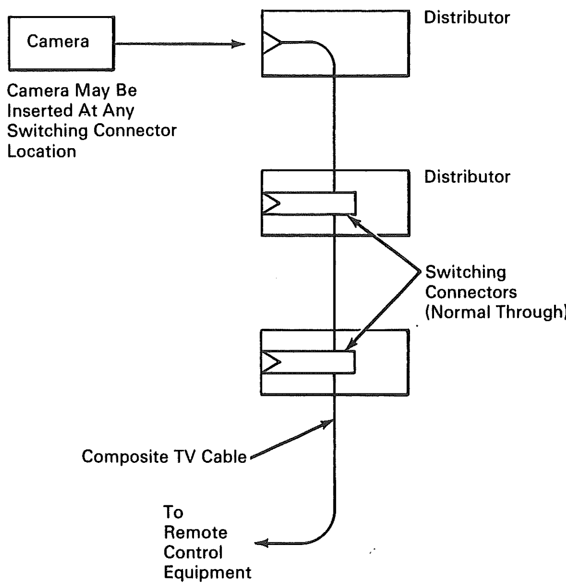
Patent status:

This invention is owned by NASA, and patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: H. E. Hobart and H. L. Minkin
(Lewis-310)

NASA TECH BRIEF

Junction Connectors Permit Strategic Placement of Television Cameras



The problem:

In closed circuit television systems, it is frequently desirable to move a camera from place to place in order to record a sequence of events or various activities of a complex operation. Past practices have involved the costly and time consuming practice of patching into the cable run at the desired locations.

The solution:

A system in which the cable run is equipped with a series of switching junction connectors at strategic locations.

How it's done:

The cable run circuit provides a series of multi-conductor connectors for coaxial cable and camera-control leads. A camera may be inserted at any one of these "stations". The cable circuit provides a normal through path for camera signals as well as control signals for the camera employed. Camera connector insertion at the "station" breaks the normal through path and connects the camera to the remote control equipment.

Notes:

1. Crimp-type contacts for mating connections reduce installation time and require a lesser level of technician skill than do soldered and potted connections.
2. Switching connectors at predetermined locations permit an entire television camera chain, including pan and tilt functions, to be plugged in where-ever needed along the composite cable with minimum effort.

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3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   John F. Kennedy Space Center
   Kennedy Space Center, Florida 32899
   Reference: B66-10391

Patent status:

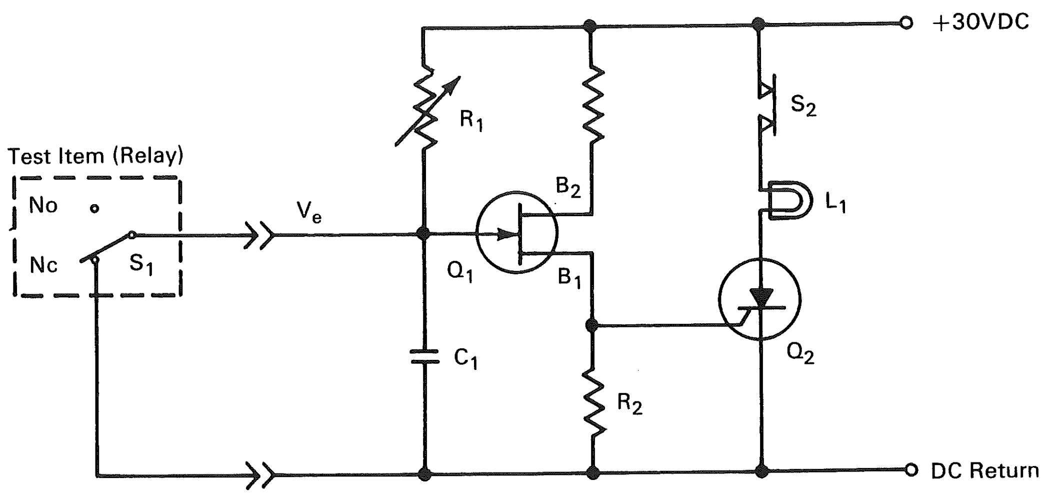
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Albert Kempson, Jr.
(KSC-66-22)

September 1966 Brief 66-10396

NASA TECH BRIEF

Solid State Detectors Monitor Relay Contacts



The problem:

To constantly monitor contact conditions in relays. Previous devices used a capacitor charge to fire a thyratron tube that triggered an indicator of some sort to show a change in contact condition. The thyratron circuit and its associated vacuum tube power supply are sensitive to external noise and power supply variations and are very difficult to calibrate. Additionally, this type detector, in multichannel applications is of standard rack size and considerable weight.

The solution:

A hand carried, solid state, 18-channel detector system that is relatively insensitive to external noise and is powered by standard 110 volt ac.

How it's done:

The normally closed contacts, S_1, of the test item maintain a short across C_1 so long as they remain closed. If the contacts open, C_1 will charge from the 30-vdc source at a rate determined by the time constant R_1, C_1. If the contacts remain open for a predetermined period (10 μsec for this circuit), the voltage V_e at the emitter of Q_1 rises and causes Q_1 to conduct. C_1 discharges through the emitter and base 1 of Q_1 and develops a voltage pulse across R_2 thus triggering Q_2 into conduction and lighting the Fail Indicator lamp, L_1. Q_2 will remain in conduction and L_1 will remain lit until power to Q_2 is interrupted by the manual opening of the Indicator Reset switch S_2.

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Notes:

1. Calibration is accomplished using an oscilloscope across R_2. The contacts of S_1 are manually opened, causing the Q_1 circuit to oscillate. By varying potentiometer R_1, the circuit time constant can be adjusted so that the free-running period of oscillation is slightly less than 10 μsec. This compensates for the initial pulse being slightly longer than the period in steady-state oscillation.
2. This 18-channel system has been successfully used in vibration and acceleration tests of Ranger and Mariner components where relay contact behavior is of significant interest.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10396

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: James D. Quinn
(JPL-785)

September 1966 Brief 66-10397

NASA TECH BRIEF

Minimum Permissible Leakage Resistance Established for Instrumentation Systems

The problem:

When an instrumentation system has been exposed to the elements, its leakage resistance to ground is appreciably affected to the detriment of system precision. Previously, such exposed systems have been dried out until leakage resistance to ground approaches infinity. This often far exceeds the precision/frequency requirements of a given system and thus results in a waste of time and money.

The solution:

Mathematical formulas are used to determine if, and to what extent, a given system should be dried out to restore minimum permissible leakage resistance.

How it's done:

One example is a system that uses transducers associated with a strain gage bridge network. The power supply minus lead of the bridge network is grounded at the test stand. Leakage from one of the bridge output leads to the stand ground unbalances the bridge. If the amount of leakage during a test changes sufficiently, the test data is invalid. Invalid data is readily identified by a significant zero shift and significant difference between post-test and pre-test electrical unbalance.

In a pressure measuring system that measures one megohm leakage to ground, system precision must not deteriorate by as much as 20%, i.e., 0.0005 (0.2 × 0.0025). To determine whether the system should be dried out or the test run without this precaution, the following formula is employed:

$$\Delta R = \frac{(10^6)^2\Omega}{10^6 + \dfrac{0.8(35{,}000)}{0.0005}}$$

$$\Delta R = 17{,}550\ \Omega$$

Where: ΔR = Change in leakage resistance during test.

This example shows that if the leakage resistance increased or decreased 17,550 ohms from the initial value of 1 megohm during test, system precision would deteriorate 0.05%. Because 17,550 ohms represents only a 1.755% change, it is likely that the leakage resistance would change by this amount. In this case, the system would be dried out before running the test.

Assuming the system dried out so that leakage to ground measures 10 megohms, the question of whether to further dry out the system or run the test is resolved by the following:

$$\Delta R = \frac{(10^7)^2\Omega}{10^7 + \dfrac{0.8(35{,}000)}{0.0005}}$$

$$\Delta R = 1.5\text{M}\Omega \text{ or } 15\% \text{ change.}$$

In this case the test would be run without further drying since it is unlikely the leakage resistance would change as much as 15% during test.

When it is assumed the leakage resistance will not change more than 20% during a test, and that a deterioration in precision of 20% of the precision classification of the system can be tolerated, the following determines the minimum permissible leakage resistance:

$$R_L = \frac{R_c}{NP}$$

Where: R_L = Minimum permissible leakage resistance; R_c = Resistance of electrical unbalance resistor for 80% deflection; N = Number of electrical unbalance resistors; P = System precision classification (0.0025, 0.005, 0.01, 0.02, etc.).

(continued overleaf)

Notes:

1. Formulas may be derived to be used for an indeterminate number of instrumentation systems that are exposed to moisture penetration.
2. Inquiries concerning this innovation may be directed to:

    Technology Utilization Officer
    Marshall Space Flight Center
    Huntsville, Alabama 35812
    Reference: B66-10397

Patent status:

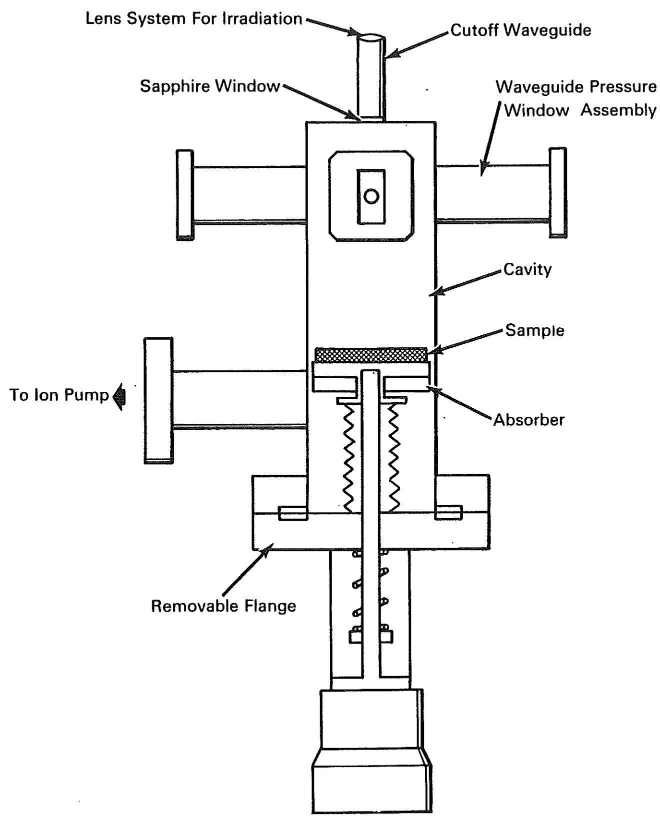
No patent action is contemplated by NASA.

Source: J. L. Perrin
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-848)

September 1966 Brief 66-10401

NASA TECH BRIEF

Dielectrometer Design Permits Measurement in Vacuum Under Irradiation



The problem:

In a vacuum environment exposed to radiation, critical components may suffer subtle changes in the dielectric constant and loss tangent of materials. For example, insulation may deteriorate as a result of flashover by outgassing or from radiation induced conductivity. Study is needed on the effects of such hostile environments on dielectric materials.

The solution:

A dielectrometer design that permits measurement of dielectric constant and dielectric losses without removing the test sample from the chamber.

How it's done:

This dielectrometer makes use of a resonant cavity to yield precise measurements of dielectric constant and loss tangent data at microwave frequencies. The

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cavity is a right circular cylinder operating in a H_{01n} mode. Cavity length is varied by a noncontacting plunger separated from the wall by a few thousandths of an inch, the plunger shaft being located by a bearing and positioned axially by a micrometer screw. Measurements are made at a fixed frequency by means of a frequency-stabilized oscillator. The Q of the cavity is inferred from the width of the resonance peak as the length of the cavity is varied. Desired dielectric information is calculated from change in cavity Q caused by the sample. Change in cavity length is a function of dielectric constant while increase in the resonant half-power is a function of the loss tangent of the sample. The dielectric samples are flat cylindrical disks that need not fit the cavity tightly since the electric field is circumferential in the H_{01n} mode and is zero at the cavity wall.

Irradiation by ultraviolet, X-, or gamma rays is accomplished through a lens system entering the top of the cavity.

Notes:

1. Although designed to simulate the effects of space conditions, this dielectrometer could also be used to simulate the effects of certain earth conditions such as exposure to sunlight or to peculiar environments.
2. A day-to-day standard deviation of 0.003 for a dielectric constant of 6.310 has been demonstrated, with an attendant accuracy on the order of ±1 percent.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10401

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Hughes Aircraft Company
under contract to
Marshall Space Flight Center
(M-FS-359)

NASA TECH BRIEF

New Computer Program Solves Wide Variety of Heat Flow Problems

The problem:

Thermal limits of materials and components frequently restrict the design of a structure. Numerous analytical solutions are available for problems with simple geometries, when the differential equations are linear. For more complex geometries, steady-state solutions may be obtained graphically or by experiment. Such methods are quite tedious and usually not applicable to transient analysis, yet the transient solution is usually needed to predict the thermal requirements in critical design areas.

The solution:

A single program called BETA (Boeing Engineering Thermal Analyzer) which uses numerical methods to provide accurate heat transfer solutions to a wide variety of heat flow problems. This highly versatile program will solve steady-state and transient problems in almost any situation that can be presented by a resistance-capacitance network.

How it's done:

In heat transfer problems involving variable physical properties and complicated geometries and boundary conditions, numerical methods offer the best solutions. The BETA program assumes that the heat flow follows the potential flow law. Other physical phenomena that follow analogous forms of this equation may also be solved by this program.

The first step in the solution is to replace the continuous physical system by a "lumped" network system analogous to a resistance–capacitance network. Numerical equations that represent this network exactly are then solved. The solution is accomplished in a step-by-step or iterative fashion. Given a network of temperatures at each node, the computer makes a pass through the network using the numerical equations to predict the temperature at each node a short time later. This process of predicting the new temperatures from the old is repeated for many iterations until the problem is solved.

Notes:

1. Both transient and steady-state solutions can be obtained for almost any system that can be represented by such a "lumped" network. This includes heat transfer problems involving conduction, convection, and radiation; mass transfer (diffusion); electrical circuits; and many other systems. Problems may be one-, two-, or three-dimensional, and may be nonlinear.
2. This program was written for the IBM 7094 computer to be used under the IBSYS system monitor. The main program and most of the subroutines are written in FAP language; the remaining subroutines are written in FORTRAN II, version 3 source language or, in some cases, symbolic language.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10404

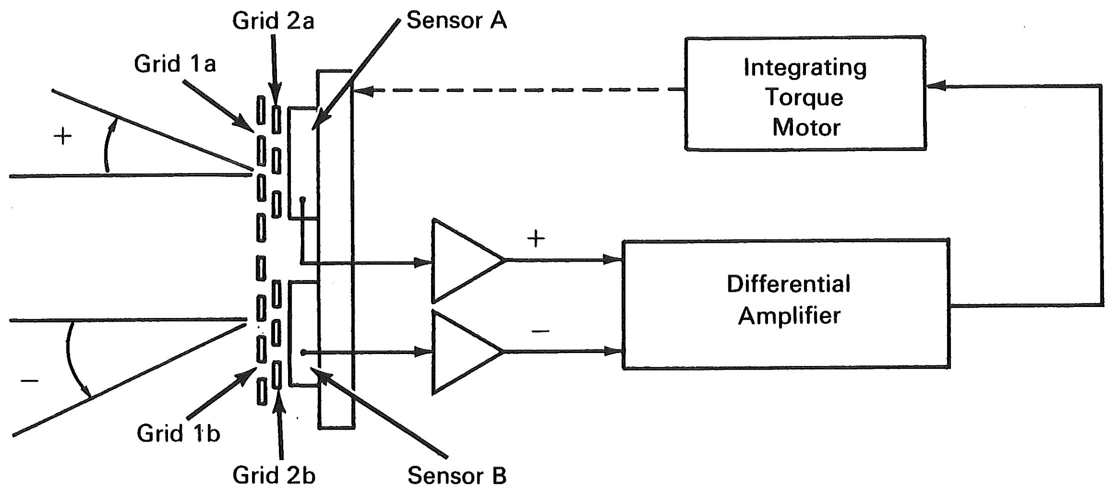
Patent status:

No patent action is contemplated by NASA.

Source: J. C. Almond
of the Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-421)
Category 01

NASA TECH BRIEF

Direction Indicator System Does Not Require Complicated Optics



The problem:

To design a direction indicator that can be used to align a system relative to a light source, such as the sun. The indicator should be simple in operation, should not require complicated optics, have no moving parts, and be able to provide very fine vernier acquisition.

The solution:

Use two photocells as light sensors to form a set. Each set indicates one direction, for example, pitch attitude.

How it's done:

Two sensors (A and B) are located side by side and each is provided with a special blocking grid in front of it. Sensor A has grids 1a and 2a that will admit light only from one side (the right side). The other sensor has grids 1b and 2b that will admit light only from the opposite side (the left side). When both sensors point at a light source the grids block the light so it will not reach the sensor. This is a null point and the output from the sensors will be zero, indicating that the system is oriented. With the system pointing to one or the other side of the light source, light will strike the appropriate sensor and there will be an output from the sensor on the side receiving the light. The output signal is used to correctly position the system.

(continued overleaf)

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California 90406
Reference: B66-10407

Patent status:

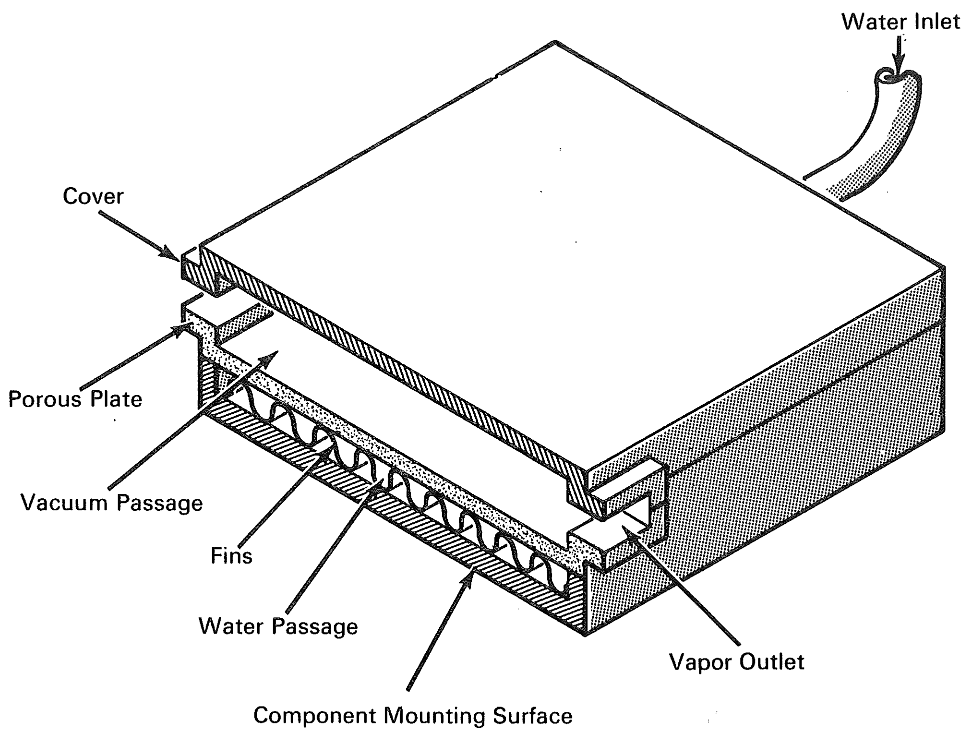
This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: James W. Mildice
of General Dynamics/Convair
under contract to
Western Operations Office
(WOO-305)

September 1966 Brief 66-10409

NASA TECH BRIEF

Modular Porous Plate Sublimator (MPPS) Requires Only Water Supply for Coolant



The problem:

To conserve the battery power of a space vehicle by eliminating a coolant pump. A conventional sublimator system requires a constant power source for a coolant pump to provide circulation of the coolant through coldplates to remove excess heat of electronic components.

The solution:

Provide modified modular sublimators for each location where heat must be dissipated, eliminating the need for an extensive coolant circulation system.

How it's done:

The modular porous plate sublimator (MPPS) requires only a water supply for coolant. The design permits heat to conduct directly from the component being cooled to the sublimator. The heat flows from the component to the MPPS water jacket, through the corrugated fins, and finally to the frozen surface in the porous plate. The water sublimes from pores of the porous plate exposed to the space vacuum, dissipating the heat into space. The MPPS is mounted in a housing that has a cover allowing the vapor to vent at a collection point.

(continued overleaf)

Notes:

1. A principal advantage of the MPPS system is the conservation of power because of the absence of a coolant pump. Overall weight and costs should not increase and the reliability factor should not be impaired. Although this concept does not provide for ground cooling (as a sublimator will not operate except in a vacuum), the system design and operation is simplified by the deletion of the pump, secondary coolant, associated plumbing, and cold plates. This simplified sublimator supplies local cooling as required by each heat source.

2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10409

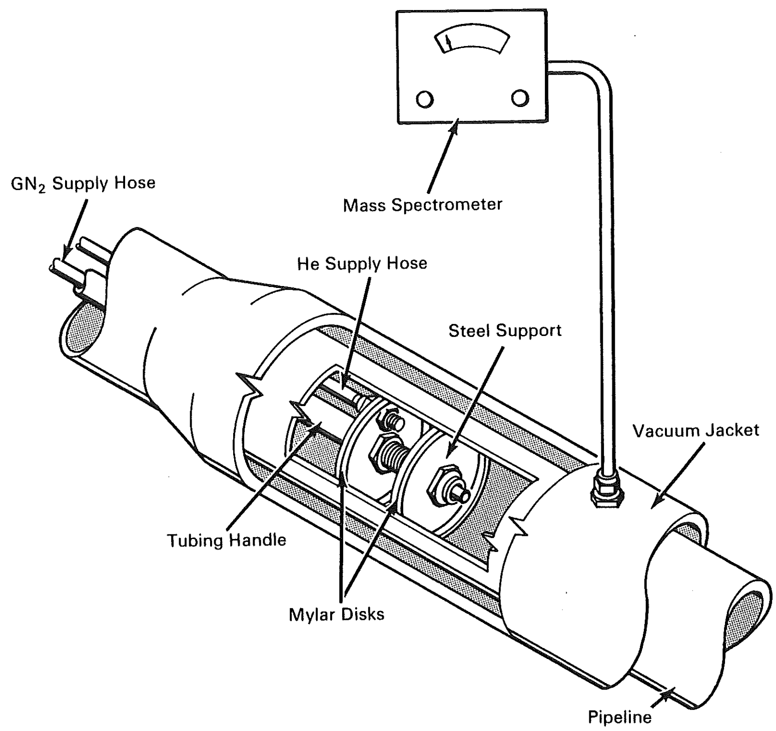
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. J. Rathbun
of International Business Machines
under contract to
Marshall Space Flight Center
(M-FS-1374)

NASA TECH BRIEF

Leak Locator for Vacuum Jacketed Pipelines Eliminates Need for Removal of Outer Jacket



The problem:

To develop a device to provide a positive means of locating leaks in a vacuum-jacketed liquid-hydrogen transfer line without having to remove the entire outer jacket.

The solution:

A leak locator, consisting of two Mylar disks, a source of nitrogen and helium gas, and a mass spectrometer, which is capable of detecting leaks in the area between the outer jacket and the pipeline.

How it's done:

The leak locator consists of two Mylar disks cut to fit the inner diameter of the pipeline. A cavity is formed by the Mylar disks which are spaced a small distance apart on a tubing handle and kept in place by two smaller steel supports. A mass spectrometer is used to monitor the area between the outer jacket and the pipeline. The pipe is first cut at a cone separator near the leak and the detector is inserted

(continued overleaf)

into that section of pipe. Low pressure gaseous nitrogen is fed through the tubing handle to fill the pipe in front of the detector. Helium is supplied to the cavity between the two Mylar disks and allowed to discharge back toward the opening. The leak locator is moved forward a distance equal to the spacing of the disks. With each move the mass spectrometer is monitored. When the leaking section falls between the detector disks, the mass spectrometer will indicate helium. The jacket may then be cut at the proper place and the pipeline repaired.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Houston, Texas 77058
Reference: B66-10412

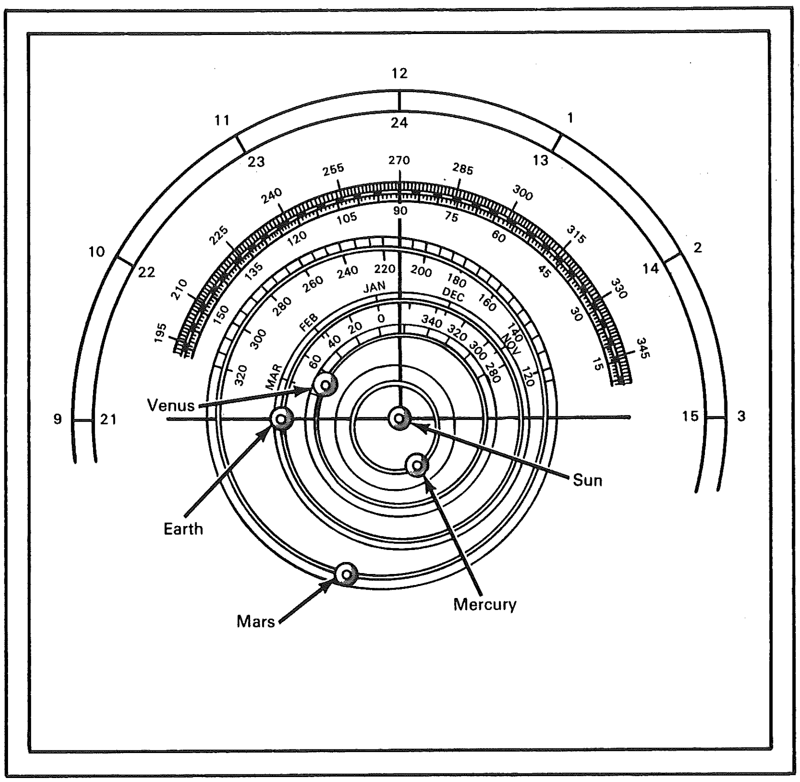
Patent status:

No patent action is contemplated by NASA.

Source: G. H. Wells
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-888)

NASA TECH BRIEF

Analog Solar System Model Relates Celestial Bodies Spatially



The problem:

To design a portable analog model of the solar system to demonstrate the true and apparent day-to-day motions of the Sun and its orbiting planets. The model should include the means to plot the paths of man-made satellites and space probes.

The solution:

A portable planetarium that indicates the relative time and space angular locations of the Sun and planets. Distance measuring scales, angular direction indicators, and typical probe trajectories are included.

How it's done:

A flat box has a small sphere located at its center to represent the Sun. Successively larger annular plates around the Sun sphere represent Mercury, Venus, Earth, and Mars respectively. These plates are properly oriented about the ecliptic pole and offset centrally to represent the actual aphelion and perihelion of

(continued overleaf)

each body's orbit as it relates to the Sun. The inclination and declination in relation to the celestial equator is readily represented by tilting the plates in predetermined positions relative to one another. Grooves in the plates are adapted to receive sliding blocks that hold small spheres to represent the four planets. Each of the annular plates has the days marked on its periphery, starting at the perihelion at 20-day intervals around the orbital plane through the aphelion and on to the perihelion again. The plate representing Earth's orbit has the months as well as the days marked about its periphery. A square plate that conforms to the normal plane of the bottom of the box is centrally mounted around the assembled annular plates in a position to represent the Sun's movement as viewed from Earth. A companion model demonstrates the yearly progress of the outer planets through the year 2000 AD. It differs from the inner planets model in relative distances represented by a factor of ×20.

Notes:

1. A goniometer and a clinometer with distance scales (in millions of nautical and statute miles) can be used to determine an individual planet's inclination or declination in relation to the earth or any of the other planets. The scale is used to measure the relative communication distances between any planet and the Sun.
2. A support on the rear of the box can tilt the model forward 23.5° to simulate the inclination of Earth's equator to its orbit plane. In addition, daily time periods and instrument coordinates for line-of-sight observation or tracking of probes or planets are indicated directly on a 24-hour clock dial.
3. To demonstrate the path of a space probe, calculations are made for a certain firing date and an overlay is prepared on clear acetate. By placing the overlay on the model, the positions of the probe in time can be quickly observed in relation to the Sun, Earth and other planets from launch through planned orbit.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10413

Patent status:

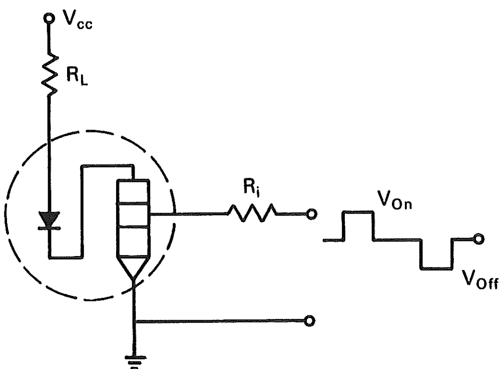
Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to the California Institute of Technology, Pasadena, California.

Source: Herbert R. Baerg
(JPL-195)

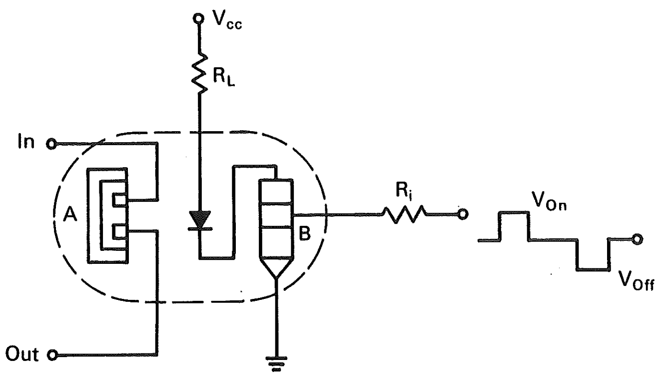
September 1966 Brief 66-10414

NASA TECH BRIEF

Electrically Controlled Optical Latch and Switch Requires Less Current



LATCH CIRCUIT



SWITCH CIRCUIT

The problem:

To design an improved electrically controlled optical latch and its related activation of an optically activated switch. In prior art, the activation of an optically activated switch was troublesome because the light source required large currents on the order of 100 ma.

The solution:

An electrically controlled optical latch composed of a sensitive phototransistor and a solid-state light source such as a GaAs light diode.

How it's done:

A small amount of base current begins to turn the transistor on from the normal off-state. The current which flows in the transistor also flows through the light source. The emitted light illuminates the transistor turning it on harder until it is driven into a latched position. It is to be noted that the light source-transistor combination must have a current gain greater than unity. To turn the device off from the latched position, a negative current must be applied to the base of the phototransistor.

The activation of an optically activated switch is troublesome because the light source requires large currents on the order of 100 ma. The switch circuit shown can be controlled and activated from a low power logic source. The light diode and phototransistor B constitute an electrically controlled light latch. The same light diode, which is equally efficient in two directions, and phototransistor A constitute the optically activated switch. Transistors A and B may be identical devices but connected in different modes.

Notes:

1. The optical latch circuit can be constructed of NPN or PNP transistors.
2. The optical latch circuit can be used as a current limiter by the insertion of an appropriate feedback resistor in the emitter lead of the phototransistor.

(continued overleaf)

3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10414

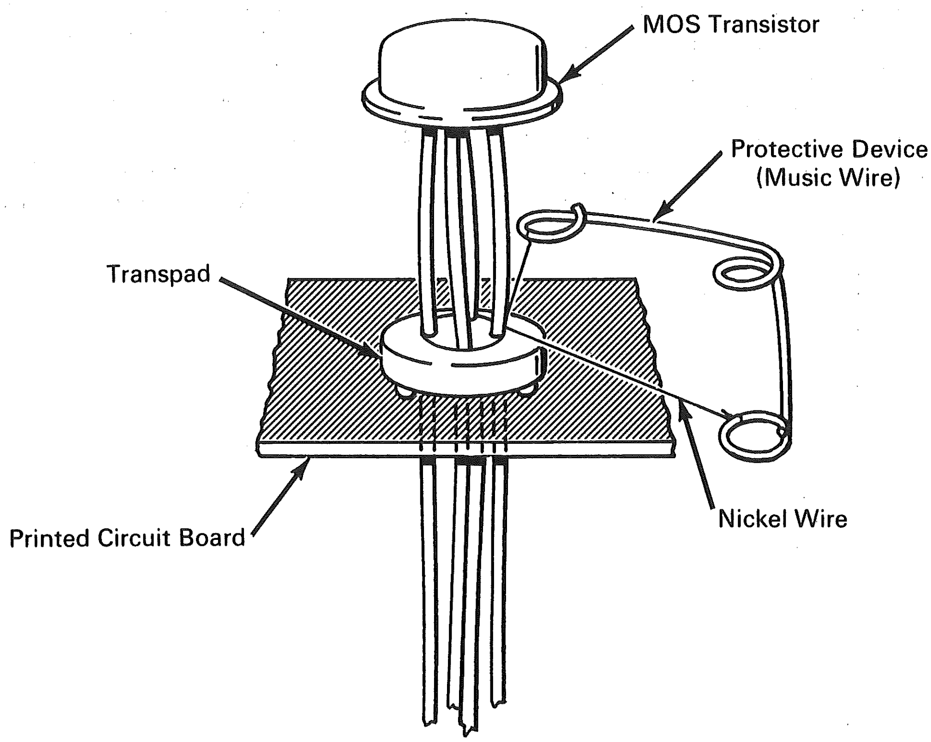
Patent status:

No patent action is contemplated by NASA.

Source: W. A. Pieczonka,
M. M. Roy, and T. H. Yeh
of International Business Machines
under contract to
Jet Propulsion Laboratory
(JPL-SC-111 & 112)

NASA TECH BRIEF

Metal Oxide Silicon (MOS) Transistors Protected from Destructive Damage by Wire Device



The problem:

To protect MOS transistors from the destructive damage that can be done when an electrostatic potential is applied even momentarily to the transistor leads when they are not shorted together. Sufficient electrostatic potential to be damaging can be generated by simple handling. Adequate protection during storage and shipping is provided by soldering the leads together or by shorting the leads together with a wrap-around piece of foil. Neither soldering nor foil is adequate, however, when the MOS transistor is ready to be placed in a circuit where the leads must be separated for assembly.

The solution:

A loop of flexible, small-diameter, nickel wire attached to a music-wire spring can be slipped over the MOS transistor case and released so that the music-wire spring tensions the loop of nickel wire around all the transistor leads, shorting them together. This permits the leads to be handled without damage to the

(continued overleaf)

transistor and makes it possible to assemble the transistor in the circuit.

How it's done:

The device consists of two short pieces of music and nickel wire. The music wire, 0.033-inch diameter, is bent to form a spring. The nickel wire, 0.007-inch diameter and long enough to form a single loop near the center of its length, is then fastened to the two outer loops of the music wire by twisting and soldering.

To attach the device to an MOS transistor, the spring is squeezed so that the loop is slipped over the MOS transistor leads until it touches the case. When the spring is released, all leads are electrically shorted to each other by the now taut nickel wire. The protective means provided by the manufacturer, e.g., twisting the leads, wrapping foil around the leads, or by soldering all leads together, may now be removed without damage to the transistor, because it is now protected by the shorting nickel wire. A transpad, which is a small disk having holes in it spaced to suit the transistor leads and which is commonly used in the construction of transistor circuits, is slipped over the leads to serve as a retaining disk.

The MOS transistor can now be soldered into a printed circuit board or into circuits using other types of construction techniques. If the circuit configuration allows, the protective device can be removed without cutting the nickel wire and thus used over again. If necessary, the nickel wire can be cut and replaced.

Notes:

1. The protective device can be used on MOS transistors having any number of leads. The leads always lie in a circle, which is convenient for the shorting action required.
2. The protective device can be replaced on the transistor to protect it should it be necessary to take it out of the circuit.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffet Field, California 94035
   Reference: B66-10419

Patent status:

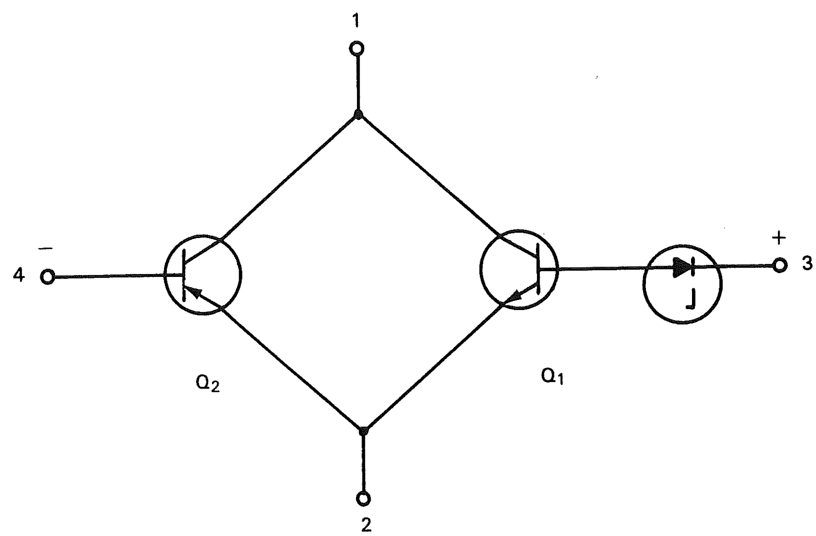
No patent action is contemplated by NASA.

Source: G. J. Deboo and E. J. Devine
(ARC-65)

September 1966 Brief 66-10420

NASA TECH BRIEF

Electronic Bidirectional Valve Circuit Prevents Crossover Distortion and Threshold Effect



The problem:

To switch or alternate an ac signal without crossover distortion or threshold effect poses a basic circuit problem. The problem becomes critical when the signal voltage level is low enough that the forward drop of a junction diode (0.5 to 1.2v) is significant. The ac signal, after passing through the bidirectional valve circuit, suffers distortion due to the diode threshold effect.

The solution:

A four-terminal network that forms a bidirectional thresholdless valve.

How it's done:

The zener voltage is selected at a level that is sufficiently low to protect the emitter-base junctions of Q1 and Q2 from reverse voltage breakdown. Terminals 1 and 2 provide the ac signal input while terminals 3 and 4 provide the dc control voltage.

A control signal must be sufficient alone or in conjunction with the instantaneous ac voltage to break down the zener diode and the base-emitter-emitter-base thresholds in order to turn on the bidirectional thresholdless valve. With the control-signal supply voltage reduced to zero, terminals 1 and 2 will block an instantaneous voltage of either polarity equal to the zener voltage. When operated from a dc current source, the ac signal current component is alternated by an amount equal to the product of gain times dc bias current.

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Notes:

1. Proper operation requires that the dc and ac signal sources be isolated electrically except at the network junction.
2. Amplitude modulation of an ac carrier is possible without crossover distortion provided the dc drive approaches a current source.
3. The prime advantage of this network is that an isolated control signal is sufficient for circuit turn-on without requiring an isolated dc power supply of sufficient capacity to carry the ac load current.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10420

Patent status:

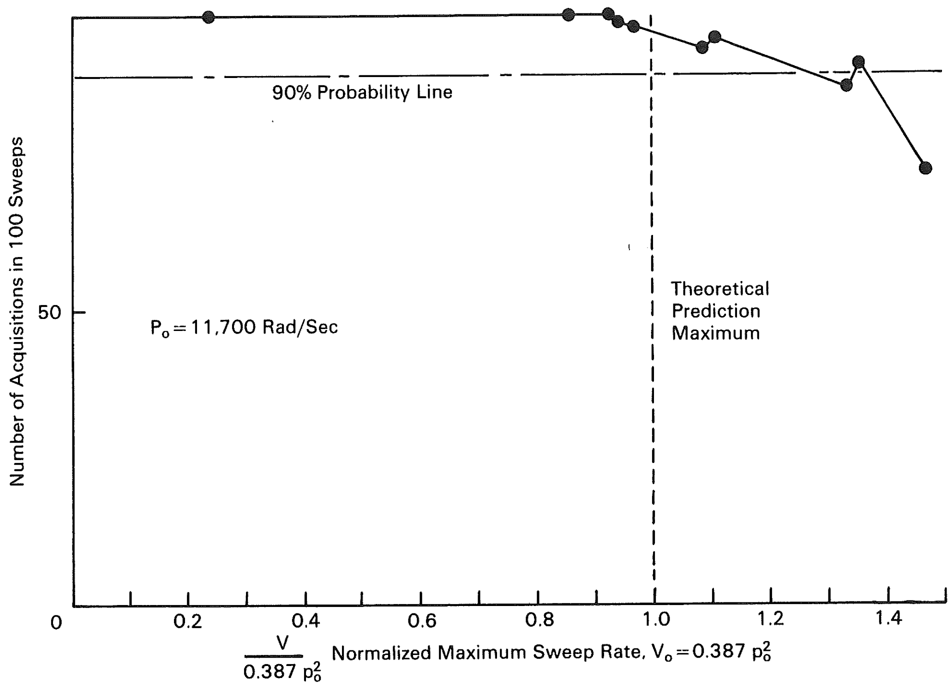
No patent action is contemplated by NASA.

Source: A. Kernick
of Westinghouse Electric Corporation
under contract to
Manned Spacecraft Center
(MSC-193)

September 1966 Brief 66-10423

NASA TECH BRIEF

An Investigation of Phase-Lock Loop Swept-Frequency Synchronization



Rapid synchronization of phase-locked oscillators is essential in many aerospace tracking and communication systems. The need arises, for example, when one ground station attempts to communicate with many satellite vehicles and must resynchronize when addressing a new vehicle or when doppler velocity uncertainty requires that a receiver search over large frequency shifts. It is the purpose of this investigation to examine the synchronization phenomena and determine the manner in which minimum acquisition time is achieved.

Essentially, the synchronization problem resolves itself into a determination of how rapidly the unknown frequency band may be searched for with certainty of acquisition as a measure of performance. The swept-frequency acquisition technique, wherein the voltage-controlled oscillator (VCO) is linearly swept through the uncertainty band, is chosen as a result of the following reasoning:

Although theory shows that unaided acquisition middle of the uncertainty band and allowing natural (setting the VCO free-run frequency initially in the feedback action to cause synchronism) occurs within

(continued overleaf)

one cycle of the initial difference frequency for a filterless phase-lock loop, it also follows that this type of loop will have a noise bandwidth approximately equal to the doppler uncertainty bandwidth. Inasmuch as additive noise is usually present in the environment of intended use (otherwise use of a phase-lock loop would not be necessary), even a small amount of input noise will reach the VCO and interfere with the synchronizing process. When a filter is inserted in the loop, the harmful noise effects are reduced, but in return the capture range (maximum difference frequencies at which the unaided loop will just synchronize) is reduced. As a consequence, the noise performance and the flexibility of having more control over the process dictate the use of the more positive swept-frequency approach.

The nonlinear, time-variant phase-lock loop differential equation is formulated for arbitrary loop voltage-controlled oscillator sweep voltages. The choice of the linear form of sweep voltage and the proportional plus integral loop filter permits a computer solution to obtain synchronization information. Bounds upon the permissible sweep-rates with associated acquisition probabilities are established after several simplifying assumptions allow utilization of the phase-plane trajectory to yield the solution. The smallest sweep-rate above which lock-on is never possible is found to be equal to the square of the loop natural frequency, P_o^2. The largest sweep-rate below which lock-on always occurs is found to be 0.387 P_o^2 (Rad/sec). Knowledge of these sweep-rate values allows the phase-lock loop parameters to be selected for acquisition within a given time interval.

Notes:

1. An experimental, linearly swept, phase-lock loop test circuit was employed to verify the results. The agreement between theoretically predicted maximum sweep rates and the observed experimental results were found to differ by less than seven percent.
2. Inquiries concerning this investigation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10423

Patent status:

No patent action is contemplated by NASA.

Source: Richard A. Dye
of Lockheed Missiles and Space Company
under contract to
Marshall Space Flight Center
(M-FS-656)

NASA TECH BRIEF

Electrical Cabling Withstands Severe Environmental Conditions

The problem:

An electrical cable that can withstand temperatures from $-150^{o}F$ to $400^{o}F$ for long periods, or $1500^{o}F$ for short periods, without losing circuit integrity. The cable would also have to perform in severe environmental conditions of vibration and water, and remain flexible and abrasion resistant.

The solution:

Develop multiconductor electrical cables that are heat, vibration, and water resistant.

How it's done:

The cable consists of nickel plated copper conductors; extruded silicone primary insulation for electrical integrity; glass braid to hold the primary construction together during a fire; and nickel plated copper shield and glass braid to add jacket strength and prevent protrusion of the shield through the jacket. The jacket is a high strength silicone extrusion which provides the moisture protection and resistance to mechanical abuse.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10427

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. D. Hathaway of
North American Aviation, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-1585)

Category 01

NASA TECH BRIEF

Computer Simulation Program is Adaptable to Industrial Processes

The problem:

Optimization of industrial processes can be greatly aided by computer simulation. Industrial processes, such as kiln drying of lumber, ceramic manufacture, and casting of large concrete structures, which involve heat and mass transfer within porous solids require complex mathematical techniques for adequate computer simulation.

The solution:

The Reaction Kinetics Ablation Program (REKAP), developed to simulate ablation of various materials, provides mathematical formulations for computer programs which can simulate certain industrial processes. The programs are based on the use of nonsymmetrical difference equations that are employed to solve systems of complex partial differential equations.

How it's done:

The REKAP program can be generally adapted to the simulation of processes involving heat and mass transfer by substituting specific parameters into the basic equations. In the kiln drying of lumber, for example, profiles of temperature, humidity, and drying time for woods of different types can be simulated to predict minimum process cost and loss of material.

The REKAP program could also be adapted to the simulation of the manufacture of ceramics, the casting of large concrete structures, and the propagation of forest fires (to determine optimum methods of control).

Note:

1. A discussion of the possible adaptations of the REKAP program is presented in a report entitled "Final Report of New Technology: Analytical Comparisons of Ablative Nozzle Materials". The REKAP computer program is described in a report entitled "Final Report: Analytical Comparison of Ablative Nozzle Materials". Copies of these reports can be obtained by addressing:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10426

Patent status:

NASA encourages commercial use of this innovation. No patent action is contemplated by NASA.

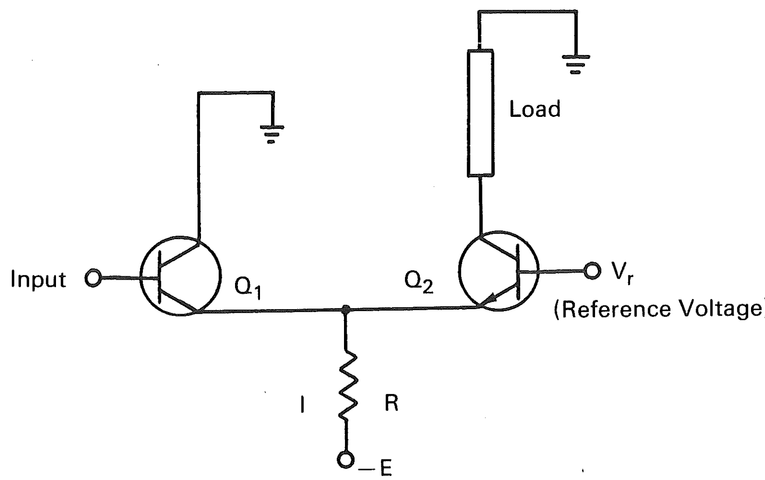
Source: F. E. Schultz
of General Electric Company
under contract to
Lewis Research Center
(Lewis-240)

Category 01

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Video Signal Processing System Uses Gated Current Mode Switches to Perform High Speed Multiplication and Digital-To-Analog Conversion



The problem:

To design a video signal processor to accept outputs from the digital computer in a visual spaceflight simulator and process them into a form suitable for presentation by the television display used in the simulator. Presentation of a view in the simulator requires that colors be assigned to the various displayed objects and textured surfaces and that surface textured patterns be faded out as a function of their scaled distance from the observer. The video signal system must be capable of accepting texture and color information in digital form and to combine these, for display on a color CRT, with analog information concerning fading.

The solution:

A video signal processor that incorporates special-purpose integrated circuits which use nonsaturating current mode switching techniques.

How it's done:

Digital color value numbers are converted to quantized analog signals by using the bits of the color number to switch discrete currents, which are made proportional to the fading signal amplitude, into the processor output stage. Signal rise time at the output of this digital-to-analog (D/A) converter is approximately 15 nsec. The processor output stage accepts the component currents, sums them, and converts the result to a voltage for driving a color CRT grid. Geometry of the output stage is arranged such that the conductors transmitting the component current to the summing point form a low impedance transmission line.

The video signal processor accepts inputs from the simulation computer and performs color selection, texture presentation, and fading. Inputs to the processor include:

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1. Texture Signals: Digital signals indicating whether surface foreground or background should be displayed on the CRT at a given instant.
2. Fading Signal: An analog signal proportional to range.
3. Object Color Selection Signals: Digital signals indicating which object face color, if any, is being presented at a given instant.

The fading information rate is relatively low (about 50 kc), but processing of texture and object color information must be compatible with 10 mc digital bit rates (rise times of 15 to 20 nsec).

Color signal amplitudes for the object faces and surface foregrounds and backgrounds are stored in the signal processing system as four-bit, binary numbers. When the electron beam is scanning a particular face or surface on the CRT, color amplitude numbers for that particular face or surface are applied to the processor.

The operation of the basic current-mode gate is shown in the figure. When the base of Q_1 (the output) is at a low voltage with respect to the reference, the emitter resistor R will carry a current whose magnitude is determined by the values of R, –E, Vr, and the base emitter drop VBE of Q_2. With its base in the "low" state, Q_1 will be off and the current in R will flow through Q_2 and through the load. If the base of Q_1 is switched to the high state, the current I will flow through Q_1 and the load will carry no current. If the magnitude of –E is large compared to VBE and to the signal swing, the current I will remain substantially constant and will be switched through Q_1 or through Q_2, depending on the state of the input.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
Reference: B66-10429

Patent status:

No patent action is contemplated by NASA.

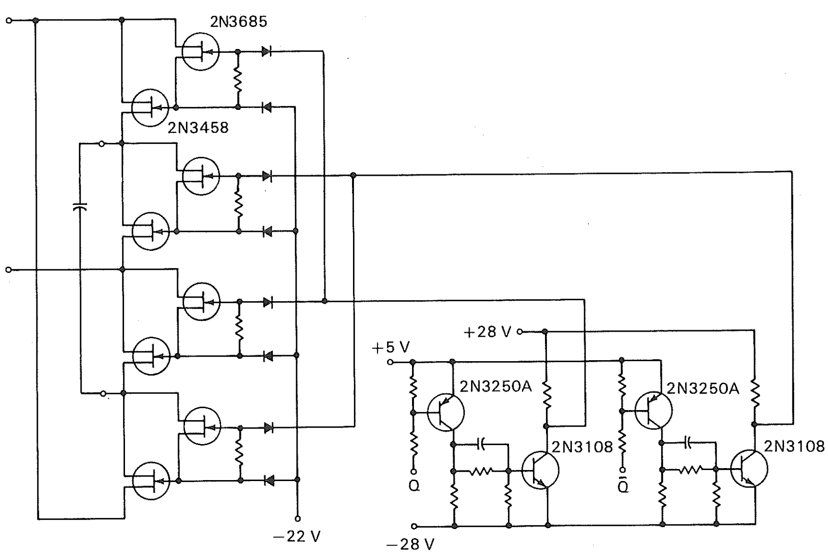
Source: M. G. Gilliland, R. S. Rougelot, and R. A. Schumaker of GE Electronics Laboratory under contract to Manned Spacecraft Center (MSC-781)

October 1966

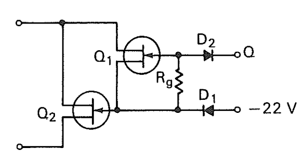
Brief 66-10430

NASA TECH BRIEF

Solid-State Switch Increases Switching Speed



Solid-State DPDT Switch



Single-Pole Single-Throw Switch

The problem:

To develop a switch for commutating capacitors in an RC commutated network that will provide greater switching speed and extend the filtering or commutating frequency spectrum well into the kilocycle region. In the past, electromechanical relays were used in the input and feedback networks of operational amplifiers where a high degree of isolation was required. These relays limited the switching speed and symmetry which could be obtained, as well as longevity and power consumption.

The solution:

A solid-state switch which is equivalent to the standard double-pole double-throw (DPDT) relay and is driven from digital micrologic circuits. Four of these switches are used in a 4-phase commutating arrangement which yields a modified notch filter characteristic. The switches are connected in series and may be used either in the input or feedback network of a differential amplifier. The switch was designed to be compatible with signal levels between ±14 volts.

How it's done:

Each DPDT switch basically consists of four single-pole single-throw (SPST) switch equivalents. The control input to the switch, Q, is either ±28 volts. When Q is −28 volts, diodes D_1 and D_2 are forward biased impressing a voltage of about 5 volts across Rg. Since the pinch-off voltage of Q_1, which is a 2N3685, is only

(continued overleaf)

3.5 volts, the potential across Rg is more than adequate to maintain Q_1 in the cutoff condition. The base of Q_2 is connected to the –22 volt supply through diode D_1 and maintains Q_2 in the cutoff condition as long as the drain and source voltage are more positive than –14 volts. This restriction is necessary since the pinch-off voltage of Q_2, which is a 2N3458, is 8 volts maximum. The pinch-off voltage of both transistors is is specified at a drain to source current of 1 nanoamp. As a result, only a very small drain-to-source current flows through the switch in the cutoff condition. Additional leakage currents on the order of 0.1 nanoamp flow from the source and drain to the gate.

When the Q input is at +28 volts, diodes D_1 and D_2 are reverse biased forcing the switch into the conducting stage. With both diodes reverse biased, the voltage across Rg decays to zero which turns on transistor Q_1. Since transistor Q_1 is connected from the gate-to-source of Q_2, it also turns on transistor Q_2. The on resistance of Q_1 is approximately 800 ohms while the on resistance of Q_2 is about 200 ohms. Since only the resistance of Q_2 is in the signal path, the switch has a series resistance of about 200 ohms.

The magnitude of Rg in part determines the speed of the switch, since it provides a discharge path for the gate capacitance. Additional capacitance may be added across diode D_2 to improve the turn-on characteristics. Using 1N4443 gating diodes and Rg = 68k, switching speeds on the order of 1 microsecond are obtained.

Four SPST switches are used in each DPDT relay equivalent, however only two of the SPST switches are on at any one time. As a result the DPDT switch has a total resistance of 400 ohms in the on condition. Leakage in the off condition is on the order of tenths of a nanoamp at room temperature.

The actual control signals, Q and $\overline{Q}$, to switch shown in circuit on the left, are 0 to +5 volt micrologic signals. A two-switch driver is used to convert this to the required ±28 volt gating signal.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California 90406
Reference: B66-10430

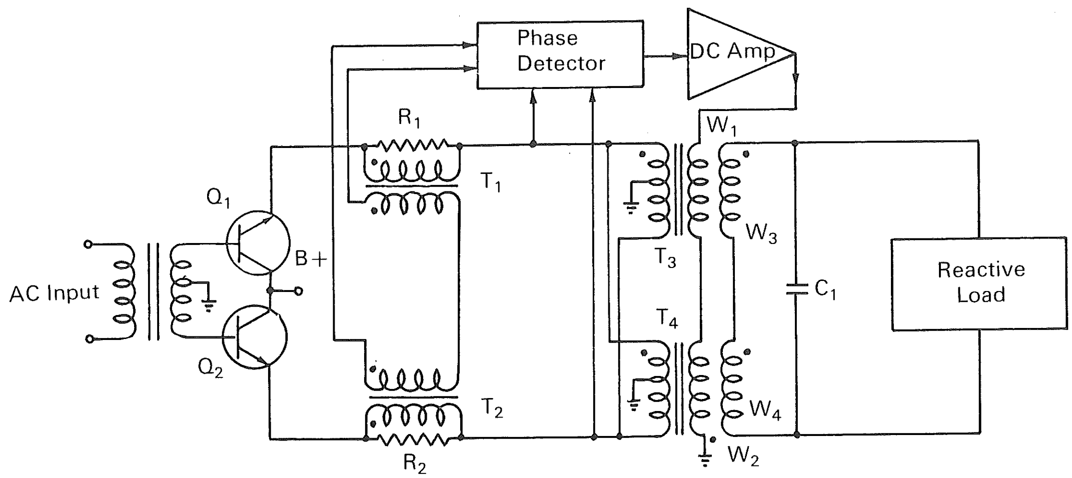
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: G. F. McGowan
of Martin-Marietta Corporation
under contract to
Western Operations Office
(WOO-298)

NASA TECH BRIEF

Control Circuit Maintains Unity Power Factor of Reactive Load



The problem:

To maintain power supply efficiency where negative load reactance changes and varies. Previous techniques inserted an inductor into the circuit if the load was highly capacitive, or a capacitor if the load was highly inductive. Should the load reactance change, it would then be necessary to change the value of inductance or capacitance inserted into the load circuit. It is required that a reactance equal to the load negative reactance be maintained in the load circuit for minimum current to produce the desired output power for the load.

The solution:

A circuit including feedback control elements for automatically correcting the power factor of a reactive load. The circuit maintains unity power factor by providing corrective error signals to the control windings of a power supply transformer.

How it's done:

Current supplied by Q_1 and Q_2 which, in effect, is the current through R_1 and R_2, is sampled by T_1 and T_2, respectively, and fed as one input to the phase detector. The other input to the phase detector is the voltage across the parallel connected primary windings of T_3 and T_4. Since T_3 and T_4 are driven push-pull, the current is sampled on both sides. The phase detector generates an error signal proportional to the angular difference between the voltage and current sampled. The error signal is amplified by the dc amplifier, and a control current developed in windings W_1 and W_2. The control current adjusts the self-inductance to drive the phase angle between the sampled voltage and current to zero. Because the control winding only reduces the self-inductance of the transformers, C_1, connected across the series-connected secondary windings W_3 and W_4 of T_3 and T_4, is chosen so that the leading current, due to C_1 alone, will be

(continued overleaf)

greater than the maximum lagging current that would result from an inductive reactive load.

Notes:

1. This circuitry will give continuous automatic power factor correction to power supply systems having a reactive load.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas, 77058
   Reference: B66-10431

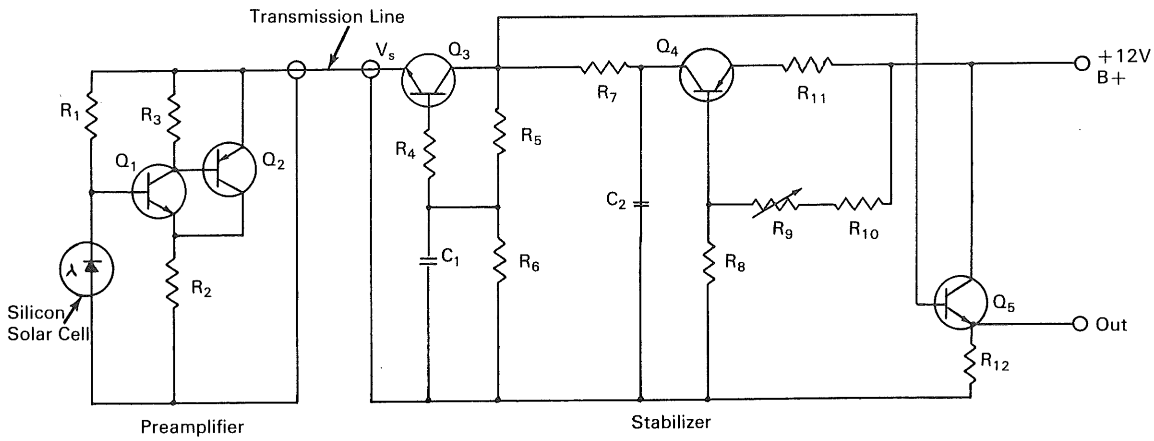
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Manuel Kramer and Louis H. Martinage
of International Business Machines
under contract to
Manned Spacecraft Center
(MSC-192)

NASA TECH BRIEF

Remote Preamplifier Circuit Maintains Stability Over Wide Temperature Range



The problem:

To design a circuit that will remain stable over a relatively wide temperature range (0^oC to 100^oC) while preamplifying light signals falling on a photocell and transmitting them through a transmission line to a remote amplifier.

The solution:

A circuit in which the preamplifier consists of a grounded emitter NPN stage followed by a PNP emitter follower which drives the signal into the transmission line. The preamplifier gets its dc power source over the same transmission line which carries the photocell signals.

How it's done:

The circuit is stabilized by dc power from a high impedance source. This same power source acts as an amplifier to ac and has an ac impact impedance equal to the characteristic impedance of the transmission line. If the amplifier were powered from the usual constant voltage supply, it would soon bias itself off because of its high sensitivity to temperature fluctuations. The stabilizer circuit provides equal currents to both preamplifier transistors over a wide temperature range. These currents are initially balanced by adjustment of R_9. When properly adjusted, the preamplifier will remain balanced over a temperature range from 0^oC to 100^oC. The preamplifier has voltage gain of 12 db, and the stabilizer 32 db. The low frequency response is limited only by the size of C_1 and C_2. The high frequency limit is fixed by the quality of the transistors used and the amount of gain required.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Western Operations Office
150 Pico Boulevard
Santa Monica, California 90406
Reference: B66-10432

(continued overleaf)

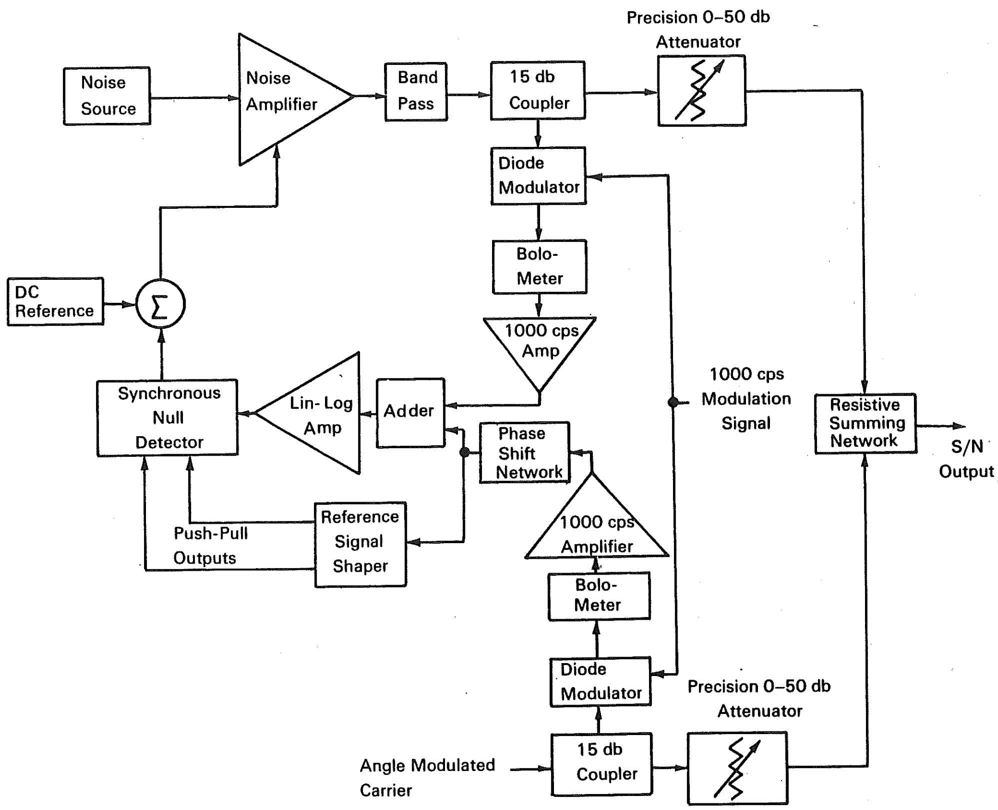
Patent status:

No patent action is contemplated by NASA.

Source: R. G. MacNaughton
of Varian Associates
under contract to
Western Operations Office
(WOO-278)

NASA TECH BRIEF

Linear Signal Noise Summer Accurately Determines and Controls S/N Ratio



The problem:

To design a linear signal noise summer that will accurately determine and control the power level ratio of two independent signals, namely signal and noise. It is often necessary in generating and measuring RF signals to know accurately the power level ratio between two independent signals. When certain types of performance tests are run on a receiver system it is necessary to mix corrupting noise with the desired signal inputs in known ratios and measure detection as a function of varying S/N ratio. The problem arises in precisely controlling the relative power levels of the signal and noise, and mixing them linearly in accurately known ratios.

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The solution:

Reference the noise power to the signal power and feed back through a servo loop any differences in power which result from changes in either of the power levels, and gain-control the noise power level. The noise power is referenced to the signal power such that changes in the signal level are not reflected as changes in S/N ratio but rather as a change in absolute signal and noise power levels.

How it's done:

Noise is generated through a temperature limited diode and is amplified to a broadband linear amplifier and band limited to a 5-pole Butterworth filter. The noise source is matched to the 50-ohm amplifier front end. The effective noise bandwidth of the system is established by the Butterworth filter.

The band-limited noise is sampled from the noise channel through a 15 db coupler and chopped at 1000 cps in a diode modulator. The modulated noise is then envelope-detected in a broadband bolometer and applied to a low noise narrow band 1000 cps tuned amplifier. The angle modulated carrier is similarly sampled, modulated, detected, and amplified to be vectorially compared with the 1000 cps detected noise envelope for synchronous null detection. The synchronous null detector provides an output about a preset dc level. The dc reference is a zener voltage adjustable in level and preset to a desired automatic gain control (AGC) operating point on the noise amplifier.

The 1000 cps carrier detected signal used as a reference signal is applied to a constant amplitude phase shifting network which has 360° of phase shifting capability without a change in amplitude. Vectorial comparison of the reference signal and noise signal is made in an adder circuit. From the adder output, the resultant signal is fed to a lin-log amplifier providing maximum sensitivity at small amplitude differences. The output of the lin-log amplifier is applied to the control grid of the synchronous detector. A second signal taken from the phase shift network output is applied through a limiter and square wave shaping circuit to a push–pull amplifier which in turn is used to drive the deflection plates of the synchronous detector. The synchronous detector difference output is then summed with the dc reference. The noise power is therefore referenced to the carrier such that changes in either of the two levels are not reflected as changes in the S/N ratio.

With the noise power level accurately defined in bandwidth through the noise filter and referenced directly to the angle modulated carrier through the feedback loop, accurate noise levels and signal levels are set through precision 50-ohm attenuators. There are two attenuators, one in each channel (i.e., the noise channel and the carrier channel) with 0–50 db range each for a total of 100 db S/N ratio range. The power levels set through the precision attenuators are then summed through a linear resistive 50-ohm network for accurate S/N ratios.

Extensive performance tests were conducted on this S/N summer with the following results:

S/N Ratio Accuracy	±.156 db over 100 db range
S/N Ratio Repeatability	±.024 db
S/N Ratio Stability	±.013 db over 4 hour period
Noise power spectral density	±.05 db over 4 Mc centered at 50 Mc

The advantages of this technique over present techniques are:

1. Improvement of S/N ratio accuracies by an order of magnitude.
2. S/N ratio accuracy does not depend on the measurement accuracy of the independent power levels.
3. Accuracy and stability of S/N ratios are attained simultaneously.
4. The technique can be used for various types of carrier modulation and for different types of independent signals not necessarily noise and carrier signals.
5. The technique is less expensive and simpler than techniques which employ independent servo loops to control the power levels.

The disadvantage of this technique is that the S/N ratios are relative and changes in carrier power are reflected as changes in the absolute signal and noise power levels.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10433

Patent status:

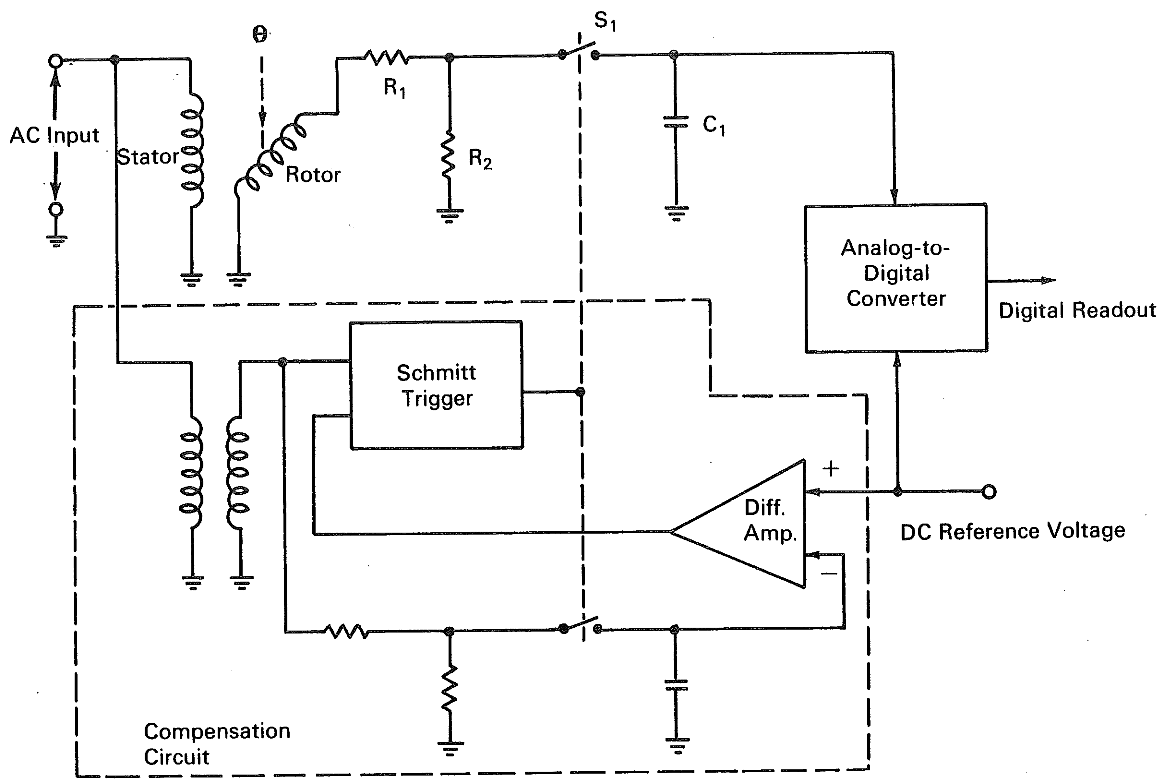
No patent action is contemplated by NASA.

Source: John L. Sundry
of Westinghouse Electric Corp.
under contract to
Jet Propulsion Laboratory
(JPL-SC-152)

October 1966 Brief 66-10436

NASA TECH BRIEF

Shaft Encoder Presents Digital Output



The problem:

To design a circuit that gives a digital indication of the position, at any given time, of a mechanical shaft.

The solution:

A circuit that includes compensation circuitry to time a capacitance relative to a reference voltage so that a digital presentation occurs that is representative of the positional condition of the mechanical shaft being monitored.

How it's done:

The monitored shaft (represented by Θ in the figure) drives a variable ratio transformer rotor. The transformer stator is excited by a sine wave ac input. Voltage across the rotor winding is applied to a voltage divider R_1, R_2 and then a sampling and averaging circuit consisting of S_1 and C_1. Capacitance of C_1 is sufficiently large so that the time constant of $C_1 - R_1 - R_2$ is substantially longer than a half cycle of the ac excitation input. In typical operation, S_1 may be

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closed during the half cycles of one polarity of the excitation waveform and open during the half cycles of opposite polarity so as to rectify the input voltage. This dc voltage, stored across C_1, is applied to the digital-to-analog converter that compares it with a dc reference voltage and provides a digital representation of their ratio in the form of binary coded pulses. Compensation circuitry adjusts the timing of S_1 so that the averaging function varies in a manner to compensate for any change in the ac excitation input with respect to the dc reference voltage so that the digital output is independent of both.

Notes:

1. This circuitry may be employed in multiples to furnish binary encoding of a number of rotating devices simultaneously.
2. Inquiries concerning this invention may be made to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10436

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

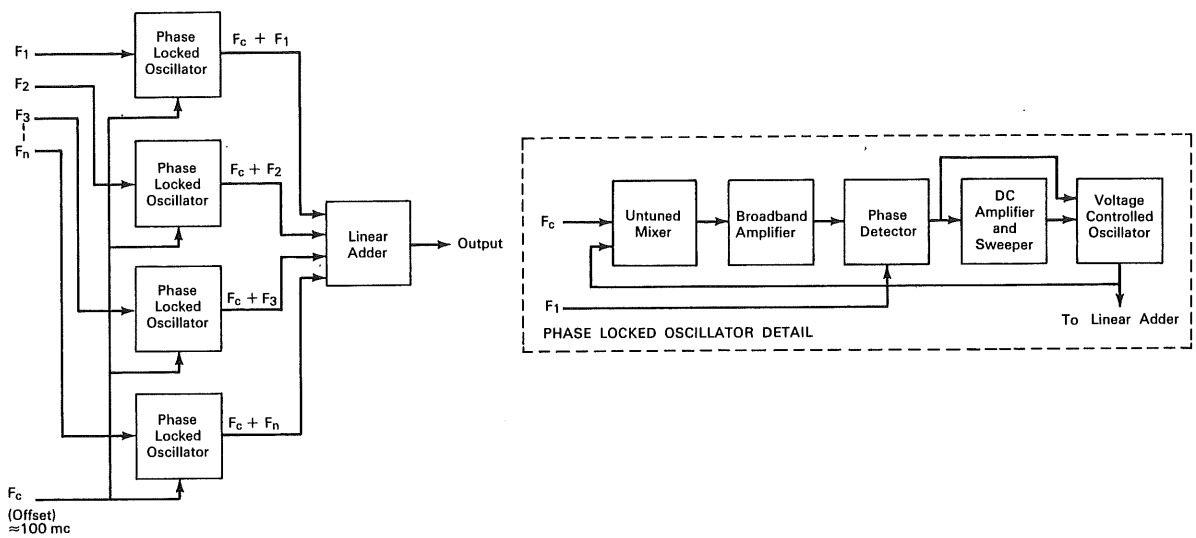
Source: Donuil Alan Hillis
of Hughes Aircraft Company
under contract to
Jet Propulsion Laboratory
(JPL-SC-191)

October 1966 Brief 66-10437

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Single-Sideband Modulator Accurately Reproduces Phase Information in 2-Mc Signals



The problem:

In the process of generating a delayed signal for a multitone ranging system, it was necessary to single-sideband modulate a series of tones at approximately 2 Mc on a 100 ±0.5 Mc carrier. A 60 db rejection of unwanted modulation products and accurate reproduction of phase information contained in the 2 Mc tones were required together with accurate amplitude control of the relative components. A conventional single-sideband modulator system did not meet these requirements. Because of the center frequency range, it was not considered practicable to provide matched filters in the conventional circuit to ensure adequate rejection of unwanted frequencies.

The solution:

A phase-locked oscillator system employing solid state components.

How it's done:

The desired output frequency is generated by voltage-controlled oscillators operated in a phase-locked loop. Adequate isolation is ensured by decoupling of the mixer from both the offset carrier and the oscillator output. The mixer, 2 Mc amplifier, and phase detector are untuned circuits whose bandwidths ensure a negligible or essentially stable phase shift at operating frequency. A sufficiently high amplifier gain is used so that a control voltage for tuning the

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oscillator over a frequency range equal to that produced by thermal drift requires only 2 to 3 degrees of phase error. Thermal drift of the dc amplifier is minimized by temperature compensation, and the phase detector diode contact potential is rendered negligible by operation at an appropriate level.

Notes:

1. This system would be useful in telemetry, aircraft communications and position-finding stations, and VHF test circuitry.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10437

Patent status:

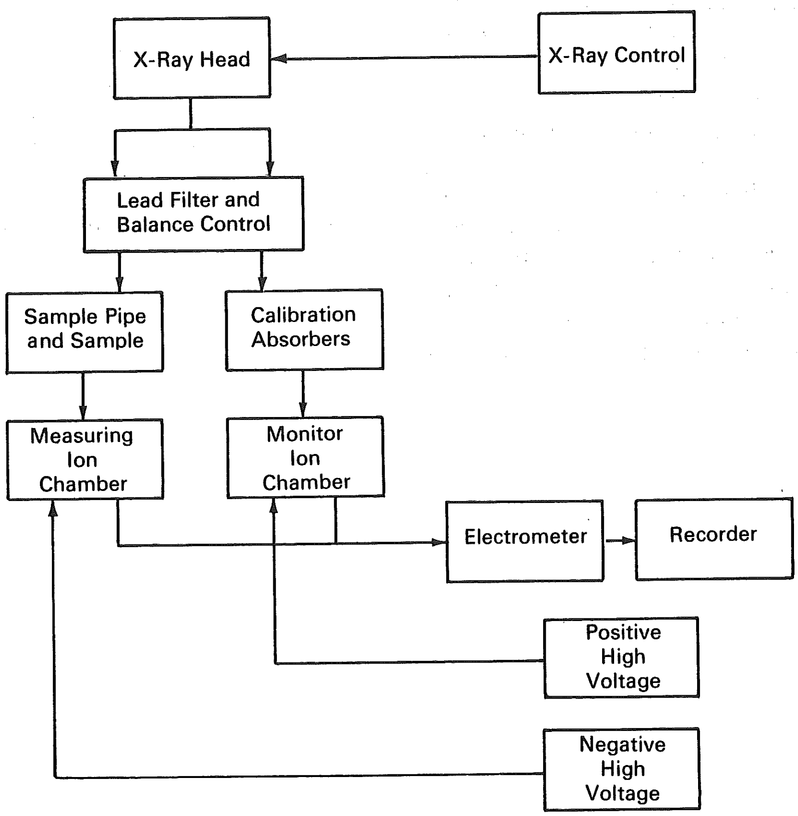
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Harry F. Strenglein
of Sperry Microwave Electronics Compnay
under contract to
Marshall Space Flight Center
(M-FS-664)

October 1966 Brief 66-10438

NASA TECH BRIEF

Densitometer System for Liquid Hydrogen Has High Accuracy, Fast Response



The problem:

To design a density measuring system for cryogenic liquids using an ionization-type detector with X-rays as the radiation source. The system must be capable of measuring the density of liquid hydrogen in vacuum jacketed lines having an inside diameter of up to 6 inches within an accuracy of 0.1 percent of the absolute density of the liquid in less than 1 second. Conventional density and thickness gages using an X-ray generator and dual ionization detectors do not meet the requirements for speed and accuracy.

The solution:

A developmental densitometer system in which the X-rays are heavily filtered with a lead shield to make the energy spectrum much less dependent on the voltage applied to the X-ray tube and which uses two balanced ionization chambers containing xenon gas,

(continued overleaf)

instead of an electronegative gas, to reduce both temperature and voltage effects.

How it's done:

The X-rays from the X-ray head are passed into the lead filter, which may be rotated slightly to change its effective thickness and thus to control the radiation fields at the two ionization chambers. One of the filtered X-ray beams is passed to the measuring ion chamber via the sample pipe and the sample to be measured. The second radiation beam is simultaneously passed through the calibration absorbers to the monitor ion chamber. These absorbers are chosen to have essentially the same effect on the X-ray radiation as the sample pipe and the sample at midscale density. At this density, the output currents from the two chambers can be made to cancel over a wide range of X-ray intensities generated at the X-ray head. Any change in the density of the sample from the midscale calibration value will result in a difference current appearing at the input to the electrometer. This signal current is integrated at the electrometer input, amplified, and displayed on an output recorder as a density change. Because of the high sensitivity of the xenon ion chambers at low energies, and the high intensity X-ray fields available, the statistical noise in the signal is low enough to provide a time constant of 0.25 second, giving system response times of less than 1 second. Power supplies of opposite polarity are used for the two ion chambers to facilitate cancellation of the output currents at the midscale density value. The electrometer, recorder, power supplies, and X-ray control are remotely located from the X-ray head, with suitable intervening shielding.

Notes:

1. Tests employing liquid hydrogen in 6-inch vacuum jacketed lines indicate that the system under development is capable of yielding density data in a response time of less than 1 second, with a 1-sigma sensitivity of $\pm 2.27 \times 10^{-5}$ kilogram per liter and an absolute accuracy of 7×10^{-5} kilogram per liter.
2. With minor modification, the system may be used with other cryogenic liquids, including liquid fluorine and liquid oxygen.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10438

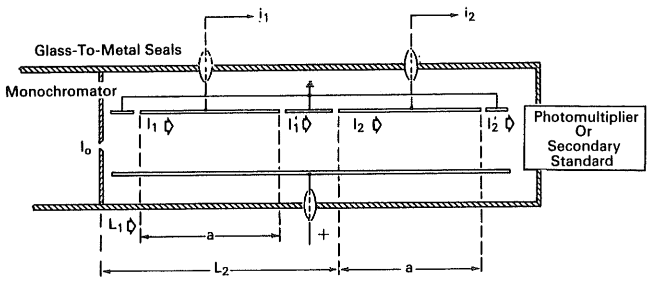
Patent status:

No patent action is contemplated by NASA.

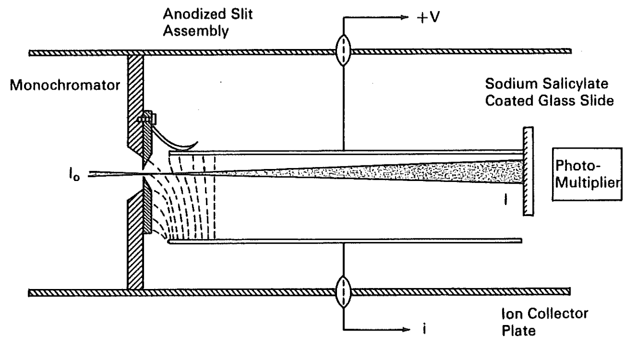
Source: Franklin GNO Corporation
under contract to
Marshall Space Flight Center
(M-FS-909)

NASA TECH BRIEF

Ion Chambers Simplify Absolute Intensity Measurements in the Vacuum Ultraviolet



THE DOUBLE ION CHAMBER



THE SINGLE ION CHAMBER

The problem:

Techniques to measure the absolute intensity of radiation in the visible and infrared region of the spectrum are well established and involve the calibration of the response of a thermopile or some other detector to radiation emitted from a National Bureau of Standards lamp. In the extreme ultraviolet region of the spectrum, however, the flux density emitted is far weaker than in the visible, making it more difficult to use a thermopile to achieve accurate measurements.

A very important parameter in the study of planetary atmospheres and in upper atmospheric research is the photoionization cross section. To obtain this parameter, it is essential to know the absolute intensity of the ionizing radiation. The importance of intensity measurements far exceeds that of measuring only photoionization cross sections. For example, the present generation of solar extreme ultraviolet measurements are made with either uncalibrated or poorly calibrated detectors, mainly because of the extreme difficulties encountered in this spectral region.

The solution:

A technique utilizing a single or double ion chamber to measure absolute intensities of radiation below 1000 Å. The ion chambers use the rare gases as the ion carrier and since each photon absorbed by the gas creates one ion pair then a measure of these ion pairs will be a measure of the number of incident photons.

How it's done:

The one direct means to determine the absolute intensity of radiation in the vacuum ultraviolet from a given source is based on the photoionization of the rare gases; however this limits its direct usefulness to radiation below 1022 Å (the ionization potential of xenon). This method is based on the assumption that the photoionization yield of the rare gases is unity. However, if the assumption is accepted, the method resolves itself to the determination of an electric current (ions/sec), which is then related to the absolute number of photons/sec absorbed by the gas. The lifetime of these radiationless transitions into the ionization continuum is of the order of 10^{-15} sec and

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therefore, they have an extremely high probability of producing an ion/photon absorbed in the autoionization region.

An experimental approach to the measurement of the photoionization yield for the rare gases is to measure their yields relative to one gas, say xenon. If these yields all turn out to be constant with respect to xenon, especially in regions of autoionization, then this is excellent evidence that the constant photoionization yield must be unity. A further check with a calibrated thermopile may lend confidence to this assumption.

Two ion chambers, a double and a single, were used to measure the photoionization yields of gases. The major advantage of the double ion chamber lies in the fact that all the variables, i.e., the two ion currents and the detector output, can be measured simultaneously, thereby eliminating any discrepancies due to light source fluctuations. The major advantage of the single ion chamber is that no measurement of an absorption coefficient is made which must obey Beer's law, which states that "the amount of light absorbed is proportional to the number of absorbing molecules through which the light passes."

Notes:

1. The simplicity and accuracy of this method of absolute intensity measurements suggests that it could become a standard for the calibration of thermocouples, thermopiles, bolometers, and other radiation detectors.
2. Further information concerning this innovation is given in "Planetary Aeronomy XI: Absolute Intensity Measurements in the Vacuum Ultraviolet," by J. A. R. Samson, in NASA contractor report, NASA CR-7, September 1963. Inquiries may also directed to:

   Technology Utilization Officer
   Electronics Research Center
   575 Technology Square
   Cambridge, Massachusetts 02139
   Reference: B66-10439

Patent status:

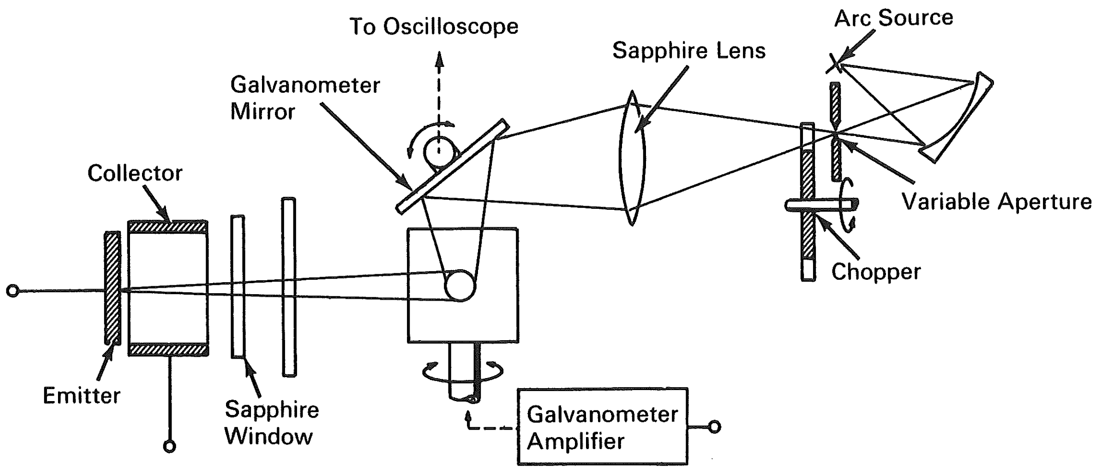
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. A. R. Sampson
of Geophysics Corporation of America
under contract to
Electronics Research Center
(ERC-10)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Photoelectric Scanner Makes Detailed Work Function Maps of Metal Surface



The problem:

To develop a scanning device that will make detailed work function maps of a metal surface in equilibrium with cesium vapor, and be capable of use over a range of surface temperatures.

The solution:

A photoelectric scanning device that maps the work function of a metal surface by scanning it with a light spot and measuring the resulting photocurrent.

How it's done:

In the photoelectric scanning device the position of the light spot is synchronized with that of an oscilloscope beam spot whose intensity is modulated by the photocurrent. The pattern on the oscilloscope, as the light spot scans the emitter surface, results in bright spots corresponding to low work function and dark spots to high work function areas. The scanner is also capable of measuring the surface work function directly by fixing the light spot on a selected portion of the emitter and measuring the work function by standard photoelectric techniques.

The photoelectric scanning device consists of the following four subsystems: optical; electronic scanning; photocurrent detection and amplification; and test cell and emitter assembly. The optical subsystem is illustrated.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10440

Patent status:

No patent action is contemplated by NASA.

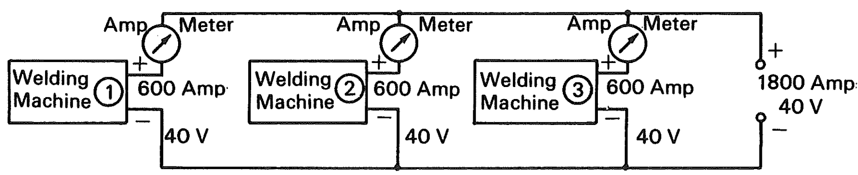
Source: Ned S. Rasor
of Thermo Electron Engineering Corp.
under contract to
Jet Propulsion Laboratory
(JPL-SC-176)

Category 01

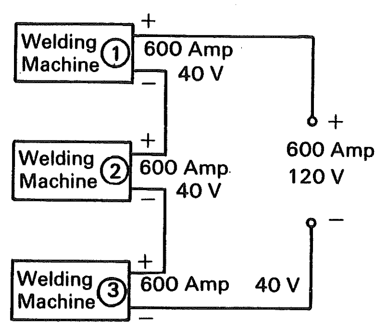
October 1966 Brief 66-10441

NASA TECH BRIEF

Standard Arc Welders Provide High Amperage Direct Current Source



Parallel Connection



Series Connection

The problem:

To obtain an adequate supply of current or voltage for various purposes such as arcs, high power magnets, and laboratory experiments. Special equipment which is now available is expensive and limited in its range of application.

The solution:

Hook up a number of standard arc welders or power supplies in parallel or series connections to obtain the desired current and voltage. This method provides maximum flexibility in a wide range of voltages and currents.

How it's done:

To obtain 120 volts for a 600 ampere dc arc at reduced pressure, 3 standard arc welders each rated at 600 amperes, 40 volts were connected in series, the total voltage then being the sum of the individual voltages: 120. To obtain high currents for large magnet coils a parallel arrangement was used. For example, 2 aircraft starters, each rated at 1500 amperes, 28 volts were connected in parallel to provide 3000 amperes at 28 volts.

Notes:

1. In the series connection, control of the arc welders permitted a variation in arc current from approximately 200 to 600 amperes with no ballast resistors required.
2. Care must be taken in the parallel arrangement to see that each unit used has nearly equal output. Gross discrepancies in outputs can cause damage to equipment and hence appropriate monitoring is needed.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10441

Patent status:

No patent action is contemplated by NASA.

Source: Joseph D. Brooks
and William D. Beasley
(LaRC-267 & 268)

Category 01

October 1966

Brief 66-10442

NASA TECH BRIEF

An Improved Method for Testing Performance of Vidicons During Vibration

The problem:

To devise a method for checking the performance of vidicons in mechanical vibration tests. Previously, performance was tested by storing a fine-detail test pattern on the photosensitive surface of the vidicon by means of a light source and lens system. The vidicon with the stored image was then placed on a vibration table and the reading beam turned on while the tube was being vibrated. With this method, however, the tube had to be moved for each test and was limited in resolution due to the distance between the overlay used to produce the image and the photosensitive surface.

The solution:

Modulate the vidicon electron beam with an external signal during the "write" period thereby storing the image on the vidicon face. No optical test pattern or lens system is employed as was the case in the previous method.

How it's done:

The photosensitive surface of the vidicon is first primed by exposing it to light. The test pattern is then stored on the primed surface by picking it up on an auxiliary camera tube and transferring it after amplification into the tube under test as video modulation of the control grid during scanning. A second method is to produce black and white bar patterns which are generated by using variable frequency scan generators with no video modulation. The photosurface is then scanned in the normal manner and the video information displayed on a cathode ray tube or display storage tube. Depending on the test requirements, the desired mechanical vibration may be applied during the storage period, the readout period, or during the entire sequence. Comparison of results obtained during a still condition and during various modes of vibration then yields the performance capabilities of the vidicon.

Notes:

1. A previous method of testing degradation of performance is described in NASA Tech Brief 66-10042, "Vibration Tests on Vidicons Made by Improved Method," February 1966.
2. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10442

Patent status:

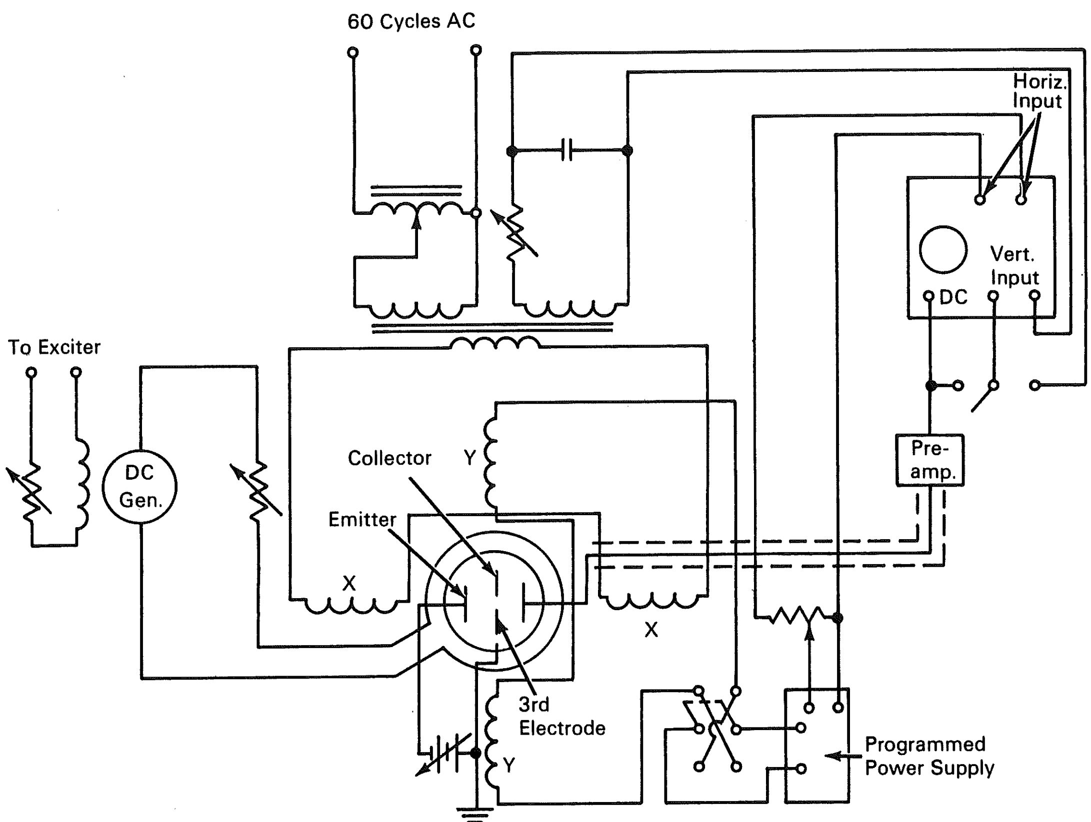
No patent action is contemplated by NASA.

Source: B. R. Corson
of Hughes Aircraft Company
under contract to
Jet Propulsion Laboratory
(JPL-SC-113)

Category 01

NASA TECH BRIEF

Thermionic Scanner Pinpoints Work Function of Emitter Surfaces



The problem:

In the testing of electron tubes such as phototubes, the metallic surface work functions of emitters are normally measured by mean values over relatively large surfaces. It would be advantageous to manufacturers to be able to make accurate spatial resolution measurements to determine local departures from the mean value.

The solution:

A thermionic scanner that uses variable magnetic fields, to sample thermionic emission in a selective manner, to determine the work function of emitter surfaces on a point-by-point basis for display on an oscilloscope.

How it's done:

The thermionic scanning system uses a set of field

(continued overleaf)

coils for collimation and controlled deflection of the magnetic field in the emitter-collector interspace. The collimating field coil surrounds the entire thermionic scanner casing while two pairs of coils are arranged in the X- and Y-axes to obtain the scanning. The X-axis coils are series connected to provide the X-deflection of the electrons and the Y-coils are series connected to obtain the Y-deflection. The Y-coils are operated at a low frequency (1 or 2 cycles per minute) while the X-coils are operated at 60 cps. Combination of the two motions generates a two-dimensional scan of the emitter surface past the aperture in the collector. Constant current for the collimating coil is supplied by a dc generator while the X-deflection coils are powered by a stepdown transformer off the 60 cps ac main. The Y-deflection current is obtained from a low-voltage, high-current regulated dc supply programmed by a sawtooth voltage from the display oscilloscope. Because this is a dc supply, only 1/2 of the emitter surface may be scanned before reversing the deflection coil connections. A field of intensity of about 200 gauss can be obtained from the deflection coils. Vertical deflection is obtained through a phase shifting circuit from an extra winding on the X-scanning transformer, while horizontal deflection is obtained directly from the time base. A negative-going sawtooth from the horizontal output terminal is used to drive the Y-deflection power supply. At this low scanning frequency, no phase problem exists.

Notes:

1. At the low scanning frequencies used, direct visual observation is very difficult and photographic techniques must be used. A film with a good range of grays must be employed to make apparent the variations in the output waveform.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10444

Patent status:

No patent action is contemplated by NASA.

Source: Ned S. Rasor
of Thermo Electron Engineering Corp.
under contract to
Jet Propulsion Laboratory
(JPL-SC-177)

October 1966

Brief 66-10449

NASA TECH BRIEF

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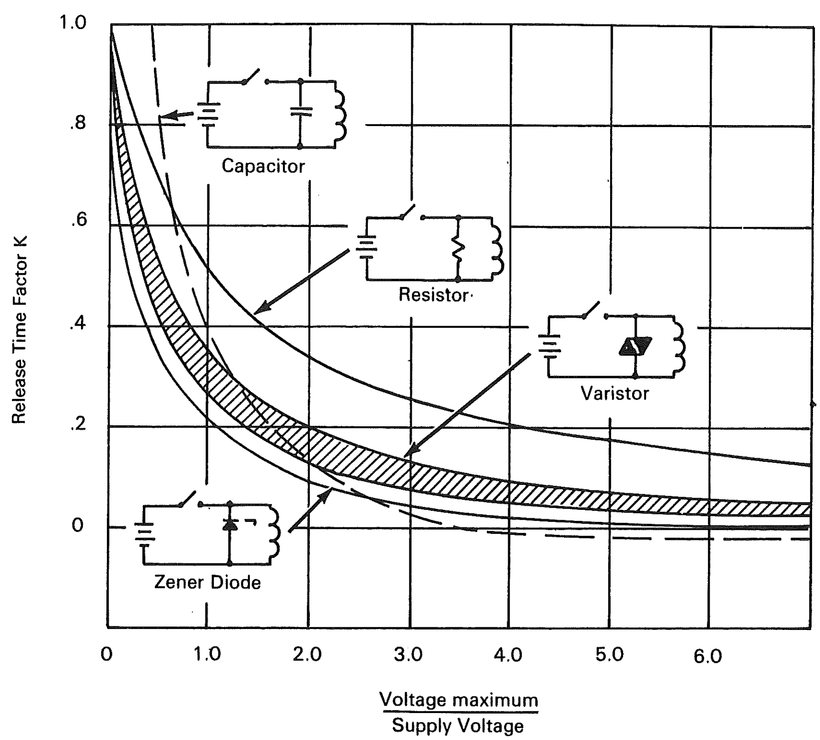
Basic Suppression Techniques Are Evaluated



GENERALIZED PLOT OF RELEASE TIME FACTOR VS. NORMALIZED VOLTAGE MAXIMUM FOR FOUR BASIC SUPPRESSION CIRCUITS

The problem:

Switching of inductively loaded circuits often causes interference in adjacent electronic equipment. Suppression can be accomplished on an individual basis by trial and error using well known techniques. Such procedures are time consuming and it is difficult to design in advance for later use during system development.

The solution:

An investigation of standard suppression methods to facilitate straightforward and consistent designs of

(continued overleaf)

optimized circuits. The data are reduced to tabular form and rapid selection of components by the designer can be made without lengthy calculations or trial and error manipulations. Release times for four suppression cases are shown in the graph and a general evaluation of basic suppression techniques is presented in the following table.

GENERAL EVALUATION OF
BASIC SUPPRESSION TECHNIQUES

Suppression Techniques	1 Reliability	2 Effectiveness			3 Arc Inhibiting Properties	4 Operate Interference	5 Physical Size	6 Design Complexity
		$V_m < E$	$V_m < 2E$	$V_m > 2E$				
Resistor	1	4-5	5	5	poor (2)	none	2	2
Capacitor	5 (1)	5-4	4	3-2	good	current-spike	5	5
Resistor-Capacitor	6	3	3-2	1	fair-good	Possible high currents	6	6
General purpose diode	3	6	–	–	fair (2)	none	1	1 (3)
Zener diode	4	1	1	2-3	poor (2)	none	3	3 (3)
Varistor	2	2	2-3	4	poor (2)	none	4	4

Notes:

(1) For ceramic capacitors the reliability is comparable to resistors. Ceramics should be used for small arc suppression capacitor. Electrolytic capacitors are the least reliable of any components tested.

(2) It is recommended that small arcing capacitors be used in these cases.

(3) Assumes an ideal component.

Column explanation:

1. Reliability: suppression circuits ranked in order of decreasing reliability.
2. Effectiveness: ranked in order of lowest attainable release time for voltage maxima indicated (first number of double rating corresponds to low region within each voltage range).
3. Arc Inhibiting Properties: (applies to arcs which occur across controlling switch contacts)
   - good—usually prevents arcing.
   - fair—arcing occurs but is greatly reduced.
   - poor—arcing occurs and is somewhat reduced.
4. Operate Interference: type of interference that will be encountered (due to presence of suppression circuit) when the solenoid is energized.
5. Physical Size: ranked in increasing order.
6. Design Complexity: ranked in increasing order of design computation complexity.

Note:

Inquiries concerning this investigation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10449

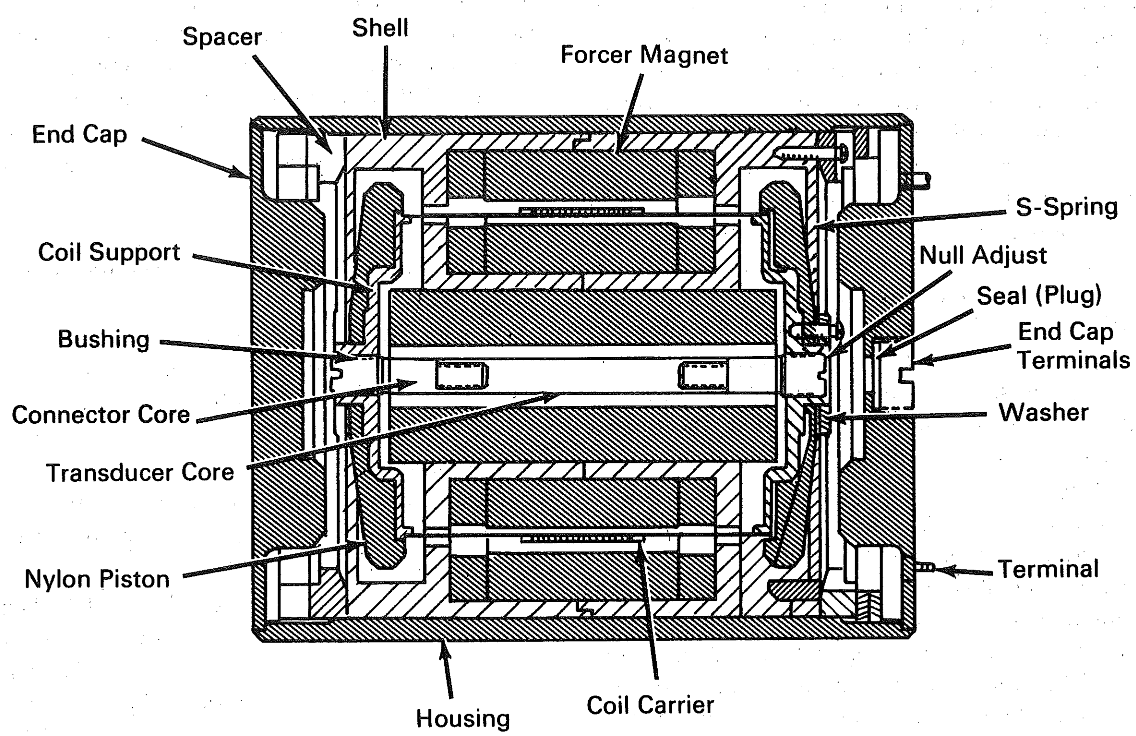
Patent status:

No patent action is contemplated by NASA.

Source: H. N. Dawirs, et al
of RECON, Inc.
under contract to
Marshall Space Flight Center
(M-FS-867)

NASA TECH BRIEF

Rectilinear Accelerometer Possesses Self-Calibration Feature



The problem:

To design a rectilinear accelerometer to operate from an ac source with a phase-sensitive ac voltage output proportional to the applied accelerations. In addition, the unit must include an independent circuit for self-test which will provide a sensor output simulating an acceleration applied to the sensitive axis of the accelerometer.

The solution:

An accelerometer incorporating the following characteristics:

Range: ±10 meters/sec/sec
Output: 0.5 volt rms/meter/sec/sec
Output Load: 20,000 ohms
Output Impedance: 2,000 ohms max (as a voltage generator)

(continued overleaf)

Null Voltage: <15 mv at 75° (<25 millivolts max)

Static Accuracy: ±½% to ±1½% (depending upon operating temperatures).

With an acceleration applied to the sensitive axis, the acceleration sensitive mass will deflect until the acceleration force on the sensitive mass is equalled by the deflection force on the S-springs. This deflection is measured by an output from the linear variable differential transformer, which is a phase-sensitive differential transformer. For self-test capabilities, a series-wound coil is mounted on the self-test coil carrier and the winding is positioned between the two permanent magnets.

How it's done:

The sensitive mass of the rectilinear accelerometer consists of nylon damping rings, coil carrier supports, and a coil carrier with its winding. In addition, the core of the transducer and its null adjustments are also included in the sensitive mass. Two S-springs are used in the assembly and are symmetrically mounted, one on each end of the sensitive mass. The sensitive mass is mounted to the ID of the S-spring which, in turn, is securely positioned to the magnet carrier.

In operation, the core links the flux lines from a primary winding into two balanced opposing secondary windings. With the core at electrical null, the in-phase signal and out-of-phase signal cancel leaving an electrical zero. With motion in either direction, an output signal proportional to the core position is achieved. Because the core is part of the sensitive mass and thus travels or deflects with it, the output signal indicates the mass position.

The self-test forcer comprises three components: the forcer coil carrier, the forcer magnets, and the magnet carriers. In design, the coil carrier is positioned within the flux gap located between the two permanent magnets. When a current passes through the winding, a force is developed which deflects the forcer in either direction depending on the direction of the current flow. The magnets are mounted in magnet carriers, which provide the magnetic flux path around the two permanent magnets. The forcer coil carrier is an aluminum drum of very thin cross section. On the OD of the aluminum drums are two ribs within which the series wound self-test coil is mounted. The two forcer magnets, inner and outer, are of a plastic permanent magnet material, which is easily formed into any cylindrical shape, and are encased in aluminum shells which mount on the ID of the outside magnet and the OD of the inside magnet to provide the necessary mechanical support. In addition, the aluminum shell also forms spacers at the end of the magnets so that they cannot come into physical contact with the magnet carriers, thus preventing the shorting-out of the magnetic fields.

The stainless steel coil supports mount on the ID of the S-springs. In addition, the coil supports also carry the coil carrier, the null adjustment of the linear variable differential transformer, and the nylon damping pistons. The dashpot damping leakage gap is between the ID of the magnet carriers and the OD of the nylon damping rings. To compensate for the change of fluid viscosity with temperature, nylon was chosen because it has a temperature coefficient of expansion much higher than the material used in the magnet carriers.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10452

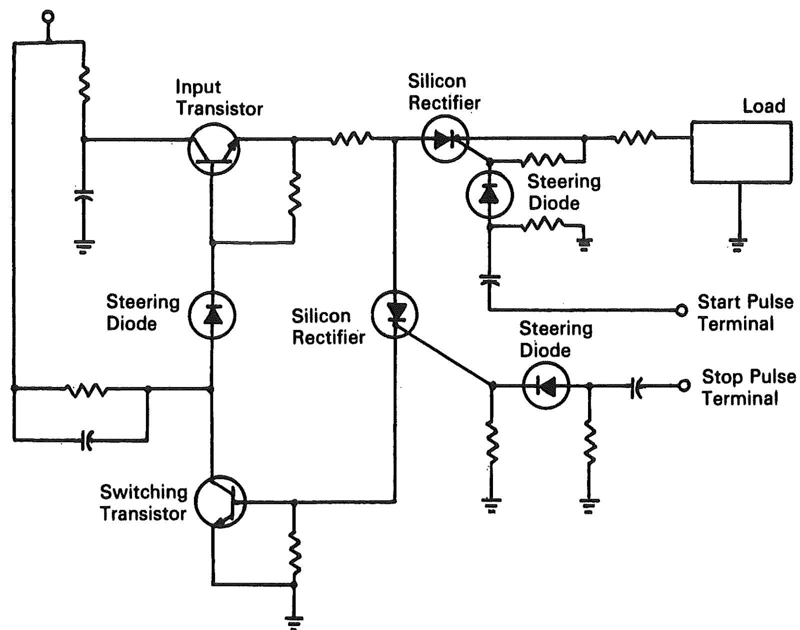
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Richard B. Henderson
of Saunders Associates, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-1480)

NASA TECH BRIEF

Pulse Generator Using Transistors and Silicon Controlled Rectifiers Produces High Current Pulses With Fast Rise and Fall Times



The problem:

To develop an electrical pulse generator utilizing power transistors and silicon controlled rectifiers for producing a high current pulse having fast rise and fall times. While the power transistor may exhibit rapid turn-on and low saturation impedance when driven into saturation, its use as a fast switch has been severely limited due to its turn-off time and storage time effects. Further, the silicon controlled rectifier (SCR), which may be easily turned on, is difficult to turn off. The two techniques for turning off the SCR are to reduce the anode current to a value below the holding current, or to drive the anode voltage below that of the cathode.

The solution:

An electrical pulse generator in which power transistors and silicon controlled rectifiers are used, and at quiescent conditions, the standby power consumption of the circuit is equal to zero.

How it's done:

The electrical pulse generator contains a storage capacitor which upon application of a pulse to the start pulse terminal is discharged into a load through an input transistor, the first silicon controlled rectifier, and a pair of resistors. Upon application of a pulse to the stop pulse terminal, the second silicon controlled rectifier is turned on causing the load current to be

(continued overleaf)

diverted through it, and also causing the switching transistor to be turned on. When the switching transistor turns on, the input transistor is turned off. Shortly thereafter the first and second silicon controlled rectifiers are turned off and finally the switching transistor is turned off. The cycle is repeated upon application of the next pulse to the start pulse terminal.

Notes:

1. In a typical application, the pulse on time (start pulse time to stop pulse time) and the circuit storage time represent a small fraction of the interpulse period (start pulse time to start pulse time). The storage capacitor under these conditions suffers negligible discharge permitting an average current to peak current ratio, which approaches the duty cycle ratio. In this manner, high pulse currents can be generated with high circuit efficiency. It should be noted that the pulse on time is determined by the turn on characteristics of the circuit elements employed, thus resulting in both fast rise and fall times for the output pulse.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10456

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Martin G. Woolfson
of Westinghouse Electric Corporation
under contract to
Manned Spacecraft Center
(MSC-405)

NASA TECH BRIEF

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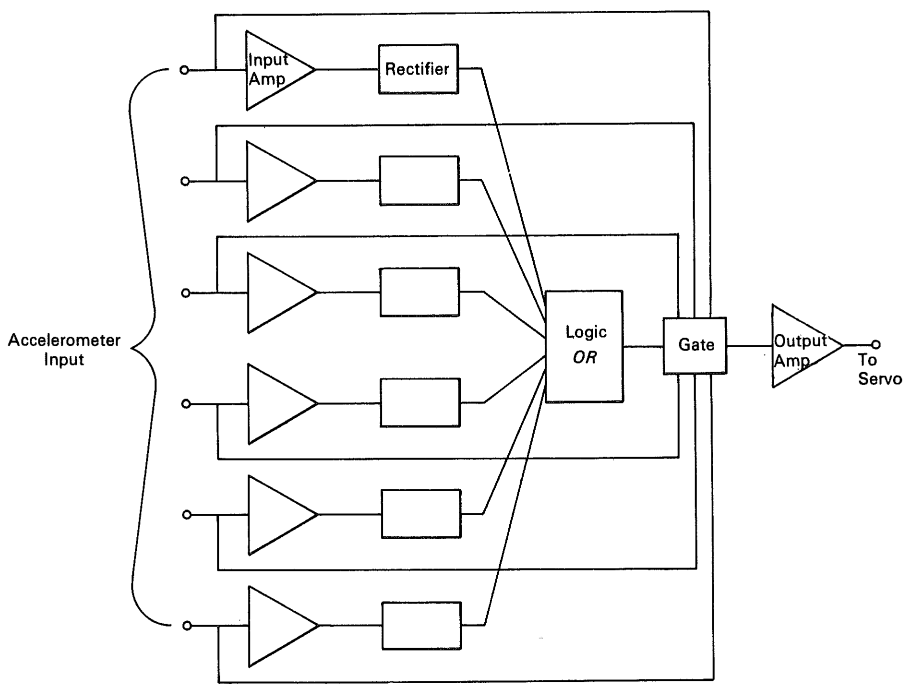
Instrument Automatically Selects Peak Acceleration Signal from Several Accelerometers



SIX-CHANNEL ACCELEROMETER SELECTOR

The problem:

To design an instrument that will automatically select the peak acceleration signal from several accelerometers used in vibration testing of large structures. The instrument must serve as a peak detector that retains the frequency information inherent in the peak signals. Conventional peak detectors do not retain all of the frequency information in these signals.

The solution:

A solid state circuit that selects the highest of several (six shown in block diagram) ac accelerometer signals and gates this signal to an output amplifier, preserving all the frequency information in the peak signal. If the amplitudes of the accelerometer signals change with time, the circuit will continually switch to the highest signal, rejecting the smaller signals.

How it's done:

The ac accelerometer signals, direct coupled to dc input amplifiers, are amplified and then rectified to produce dc voltages proportional to the accelerometer input signals. These dc voltages are coupled to a logic *or* circuit, which controls the gate. Only the

(continued overleaf)

peak signal that has the highest instantaneous dc value is gated to the output amplifier, which provides either gain or attenuation and isolation. The signal from this amplifier is fed to a standard servo system which controls the vibration levels applied to the accelerometers mounted on the test structure.

Notes:

1. Several multichannel selectors can be connected in such a manner that the output from each additional selector is fed into any one of the channels of the next selector. The output amplifiers would be set for unity gain.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10462

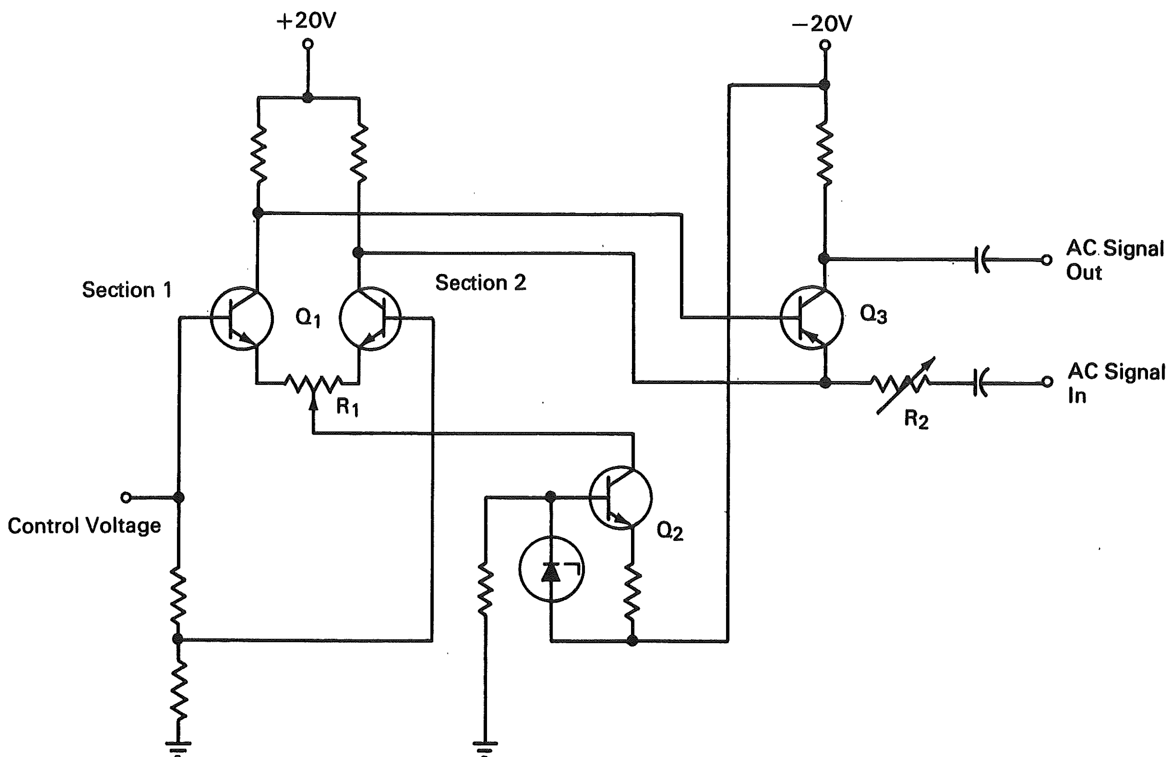
Patent status:

No patent action is contemplated by NASA.

Source: Carl P. Chapman
(JPL-816)

NASA TECH BRIEF

Solid State Circuit Switches AC Load



The problem:

To design a solid state circuit that will switch ac signals with peak amplitudes greater than 5 volts. Prior art devices have been able to control dc voltages only.

The solution:

A differential amplifier circuit that biases a switching transistor on and off by a 0.1 to 5.0 dc control voltage.

How it's done:

The circuit consists of a dual NPN transistor, Q_1, a current source, Q_2, and an ac switch, Q_3. Resistors R_1 and R_2 are initially adjusted to obtain proper switching action and to control the ac gain of the switch. With no dc control voltage applied, the collectors of Q_1 will essentially be at the supply potential of 20 vdc causing the base and emitter of the switch Q_3 to be at this same potential. In this condition, Q_3 will not conduct and there will be no ac signal out.

(continued overleaf)

Applying a dc control voltage of 0.1 to 5.0 volts to the base of section 1 of Q_1, causes that section to conduct more heavily than section 2. Thus, the collector of section 1 will be at a lower voltage than the collector of section 2, causing Q_3 to be forward biased to conduct and pass the ac signal.

Notes:

1. Transistor Q_2 provides a constant current source for Q_1 for more stable operation. Resistor R_1 determines the on/off sensitivity of Q_3 by unbalancing Q_1. Resistor R_2 is the signal gain potentiometer and is adjusted for unity gain so that 1 volt of input signal produces 1 volt of output signal.
2. Output of this switch is flat within 3 db from 6 cycles to 21.5 kc using 1 mfd coupling capacitors.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10465

Patent status:

No patent action is contemplated by NASA.

Source: Carl P. Chapman and Donald R. Rupnik
(JPL-798)

NASA TECH BRIEF

Study Compares Methods for the Numerical Solution of Ordinary Differential Equations

The problem:

To determine which of the many available methods for the numerical solution of ordinary differential equations is the most efficient by evaluating the performance of each of the alternatives in solving identical problems.

The solution:

A report prepared for Marshall Space Flight Center by the Georgia Institute of Technology that compares the use of five different methods for the computer solution of the restricted three-body problem. The report, entitled "Study of Methods for the Numerical Solution of Ordinary Differential Equations," describes the implementation of each method on a Burroughs B-5000 computer and in terms of speed and accuracy.

How it's done:

The following methods for integrating nonlinear coupled differential equations were tested in the study:

a. The single-step Lie Series method
b. The multistep Cowell method
c. The multistep Adams method
d. The single-step Runge–Kutta–Fehlberg method
e. The single-step Runge–Kutta–Shanks method

Each of these methods was applied to the same set of equations, and all were programmed on the B-5000 computer to obtain a comparison in terms of speed and accuracy. The differential equations tested were the equations of motion of an earth–moon satellite using the simplifying assumptions that the earth-to-moon distance is constant and that a satellite remains in the plane of the lunar orbit. Periodic orbits are known for this system, and a check for periodicity provides a gage of accuracy for each method.

Programs for each method were written in double-precision floating-point arithmetic (23 decimal places) in Extend Algol for the B-5000 computer. A series of runs was made on 3 different Arenstorf orbits at various orders from 7 to 16 and accuracies from 10^{-12} to 10^{-16}.

Each of the five methods is discussed in detail in a separate section of the report. Each section contains an introduction, a description of the mathematical method, a discussion and an explanation of a computer program utilizing the method, and a flowchart and program listing. A summary section compares the advantages and disadvantages of each method and suggests applications for each method.

The overall conclusions reached were that each of the methods, except that of Cowell, could be considered effective, but the methods of Runge–Kutta–Shanks and Runge–Kutta–Fehlberg were the best. At the highest accuracies and orders, where Runge–Kutta–Shanks formulas are not available, the Runge–Kutta–Fehlberg method was superior.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10466

Patent status:

No patent action is contemplated by NASA.

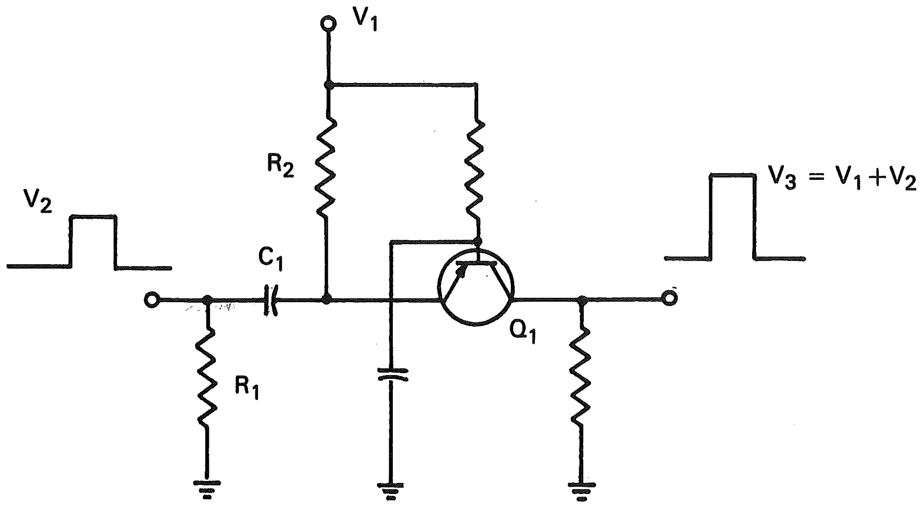
Source: Georgia Institute of Technology under contract to Marshall Space Flight Center (M-FS-830)

Category 01

October 1966 Brief 66-10480

NASA TECH BRIEF

Simple, One Transistor Circuit Boosts Pulse Amplitude



The problem:

A requirement existed to supply a pulse voltage, higher than that normally available from emitter-follower circuits, to drive a 100-watt transmitter.

The solution:

A simple circuit that uses a single transistor to accomplish capacitor storage followed by common-base switching.

How it's done:

Capacitor C_1 is charged through R_1 and R_2 to the supply line voltage, V_1. With no input pulse, both the emitter and base of the transistor are at the same potential, and the collector is cut off. With an input pulse V_2 present, the potential of C_1 with respect to ground is increased by V_2. The emitter becomes more positive than the base and the transistor is switched on. This results in an output pulse, V_3 that is equal to V_1+V_2, minus negligible losses in C_1 and the transistor.

Notes:

1. In order for C_1 to reach approximate full charge between pulses, the ratio of charging interval to charging time constant must be much greater than the ratio of discharge interval to discharge time constant.
2. In tests, this circuit has produced a good output waveform at about twice the amplitude of the supply line voltage, V_1.
3. Inquiries concerning this innovation may be made to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10480

(continued overleaf)

Patent status:

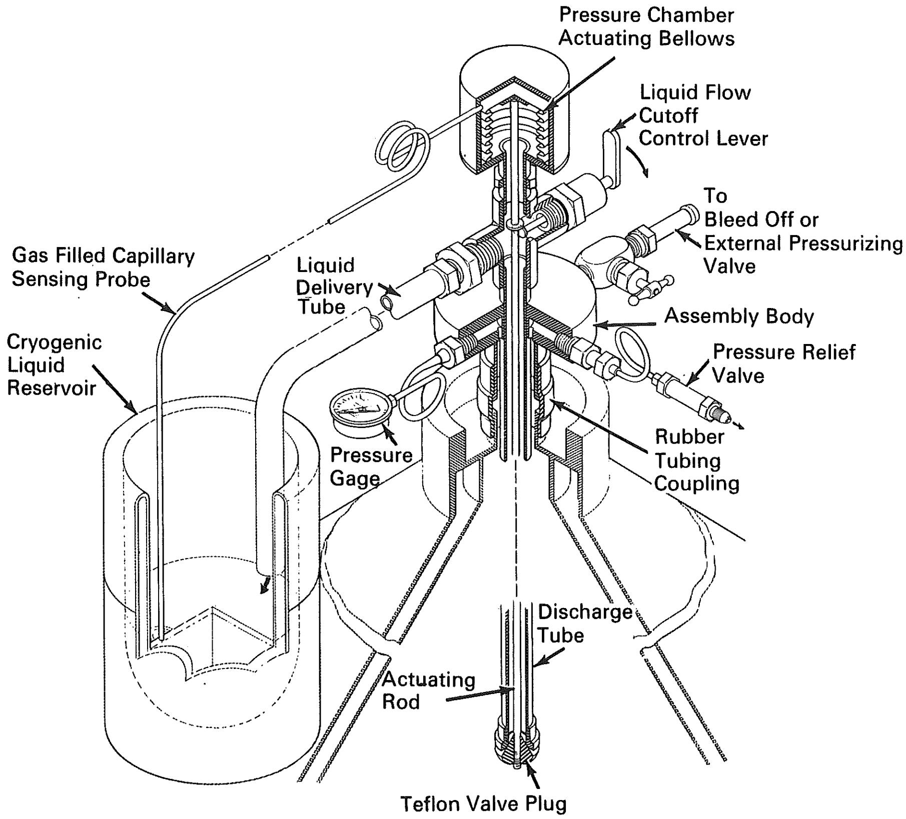
No patent action is contemplated by NASA.

Source: M. W. Matchett and T. Keon
of Cutler Hammer
under contract to
Goddard Space Flight Center
(GSFC-501)

October 1966 Brief 66-10482

NASA TECH BRIEF

Automatic Cryogenic Liquid Level Controller Is Safe for Use Near Combustible Substances



The problem:

To develop an automatic cryogenic liquid level controller that is independent of an external source of power for its operation. The shortcomings of externally powered controllers are: (1) if the power fails the equipment becomes inoperative, and (2) if the device is used in the presence of combustible substances such as liquid hydrogen, there is a definite safety hazard.

The solution:

An automatic mechanical liquid level controller that is independent of any external power sources. A gas filled capillary tube leads from a pressurized chamber and becomes a liquid level sensing element or probe.

How it's done:

The gas filled capillary tube sensing element is inserted into the cryogenic liquid reservoir or cold trap,

(continued overleaf)

whose liquid level is to be maintained. When the liquid drops below a desired level or end of capillary tube, the change (or increase) of gas pressure in the capillary tube compresses the bellows, which is enclosed in a nitrogen gas pressurized chamber, transmitting a downward movement through the actuating rod causing the valve plug to leave its seat. Cryogenic liquid in the supply tank flows up through the delivery tube and out into the liquid reservoir. When the liquid in the reservoir rises to the desired level and contacts the capillary tube, the gas pressure in the capillary tube drops, permitting the bellows in the pressure chamber to expand due to its own inherent spring action, and the associated ambient pressure differential. The actuating rod attached to the bellows rises causing the valve plug to be seated, stopping the flow of cryogenic liquid up through the delivery tube.

Notes:

1. This system is entirely mechanical in operation and can be used with the utmost safety in the presence of combustibles because there is no electrical spark hazard involved. Another desirable feature of this system is its complete portability.
2. The safety or pressure relief valve shown is set to unload at approximately 7 psig (which has been found to be safe for metal dewars). The long stainless steel goosenecks on the pressure relief valve and pressure relief valve and pressure gage are to prevent frosting of these units due to atmospheric moisture.
3. Inquiries concerning this innovation may be directed to:

    Technology Utilization Officer
    Lewis Research Center
    21000 Brookpark Road
    Cleveland, Ohio 44135
    Reference: B66-10482

Patent status:

No patent action is contemplated by NASA.

Source: Mylo Krejsa
(Lewis-195)

October 1966

Brief 66-10486

NASA TECH BRIEF

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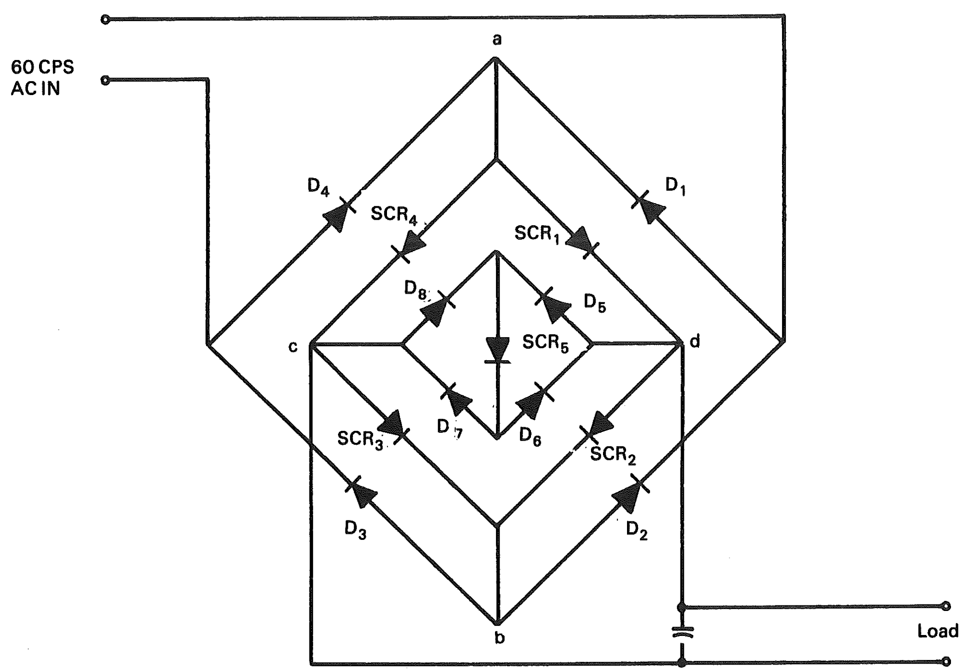
Solid State Circuit Controls Direction, Speed, and Braking of DC Motor



The problem:

Various solid state devices are used to control the speed of dc motors, but do not provide for reversing or braking which are required for accurate positional control of large inertial loads.

The solution:

A full-wave bridge rectifier circuit in which the gating of silicon controlled rectifiers (SCR's) controls output polarity. Braking is provided by an SCR that is gated to short circuit the reverse voltage generated by reversal of motor rotation.

How it's done:

Diodes D_1 through D_4 form a conventional full-wave bridge providing full-wave pulsating dc voltage between points a (positive) and b (negative). Point a is connected to a bridge consisting of SCR_1 through SCR_4. By gating SCR_1 and SCR_3, an external load will see point d positive with respect to point c. If SCR_2 and SCR_4 are gated, the opposite condition will exist. Braking is accomplished by gating SCR_5 after removal of the gate signals from SCR_1 through SCR_4. SCR_5 then short circuits the voltage generated by the armature rotation. The capacitor keeps voltage transients from misfiring the SCR's.

(continued overleaf)

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10486

Patent status:

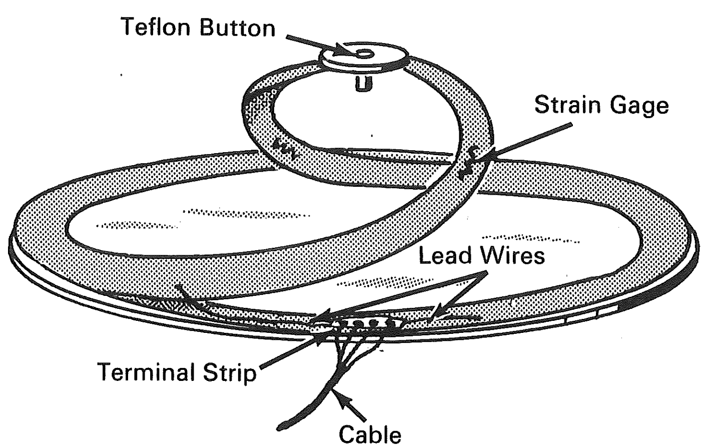
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Michael F. Hanna
(JPL-757)

October 1966 Brief 66-10488

NASA TECH BRIEF

Spiral Spring/Strain Gage Combination Accurately Measures Shock Induced Deflection



The problem:

To measure deflection between two relatively inaccessible surfaces in a drop test that causes them to close to near flatness. Prior methods used nonresilient blocks whose depth was measured before and after impact, but too many variables entered deflection calculations and no permanent record could be made at moment of impact.

The solution:

A spiral spring (or springs) equipped with strain gages hard-wired to readout instrumentation.

How it's done:

Two strain gages are fastened to each spiral spring in such a way that deflection of the spring causes equivalent deflection of the gages. A constant dc voltage is fed to the two gages, whose output is indicated on appropriate instruments, including a strip chart recorder. In a drop test, impact causes the springs to be compressed, thus deflecting the strain gages and changing their electrical resistance relative to the amount of deflection. The resultant change in strain gage dc output is simultaneously indicated on a voltmeter and recorded permanently on the strip chart.

Notes:

1. This technique has been successfully used on Apollo drop tests to measure deflection between aft bulkhead and heatshield.
2. This could be of value in industrial testing for manufacturing requiring precise gap measurement in inaccessible areas.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10488

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. R. Walker and B. R. Berven
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-789)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Battery Charge Regulator Is Coulometer Controlled

The use of nickel/cadmium type primary cells in space applications is attractive in that these cells are capable of accepting a relatively high rate of charge without degradation. This is particularly important in the case of a satellite whose orbit involves a relatively short period in sunlight. To take advantage of the nickel/cadmium cell's tolerance for high charging rate, it is desirable to have a charge control method that permits maximum charge rate right up to full charge level.

Because the nickel/cadmium cell does not exhibit the end-of-charge voltage upswing except at very low temperatures, it is very difficult to control the charge by a voltage clamping method at normal operating ambients. Such techniques as voltage/current limiting, specific temperature control, and straight current limiting have been used in the past to control rate of charge but, generally speaking, either permit unnecessary overcharge or take excessive time.

A coulometer controlled battery charge regulator has been designed around a cadmium–cadmium type cell that overcomes the aforementioned disadvantages. This cell exhibits a characteristic whereby the voltage drop is approximately 50 millivolts until the coulometer's rated ampere hours have passed through the cell, at which time the voltage increases very rapidly. The same characteristic is also exhibited in the opposite direction. When a portion of the ampere hour value has been reversed and then recharged, a minor hysteresis loop is traversed. The coulometer voltage will rise when the same ampere hour value has been put back in as has been removed. The use of the coulometer as an ampere hour measuring device permits all available current to go to the battery until full charge state is reached, at which time the charge rate is automatically reduced.

Notes:

1. In view of the current interest in nickel/cadmium cells as energy sources for automotive vehicles, this method of charge control should be quite attractive for its time saving feature.
2. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B67-10446

Patent status:

No patent action is contemplated by NASA.

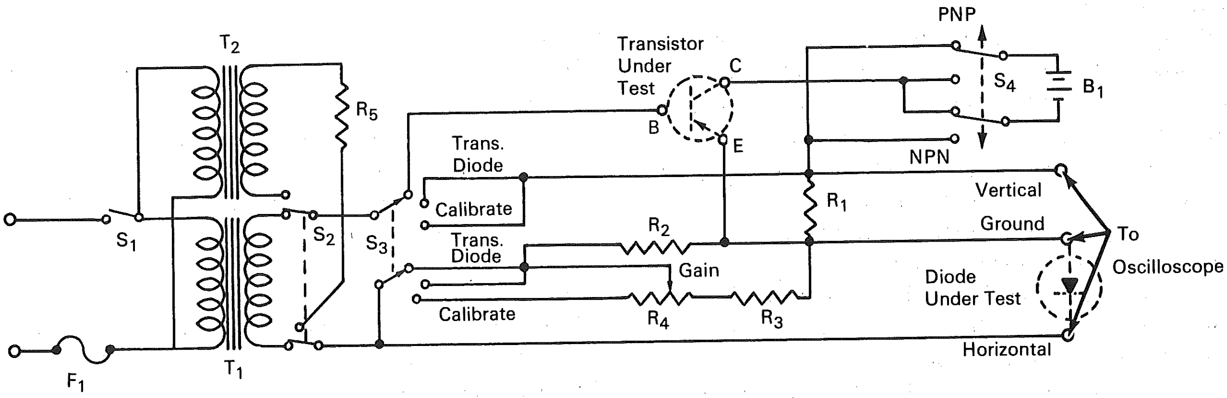
Source: John Paulkovich
(GSFC-561)

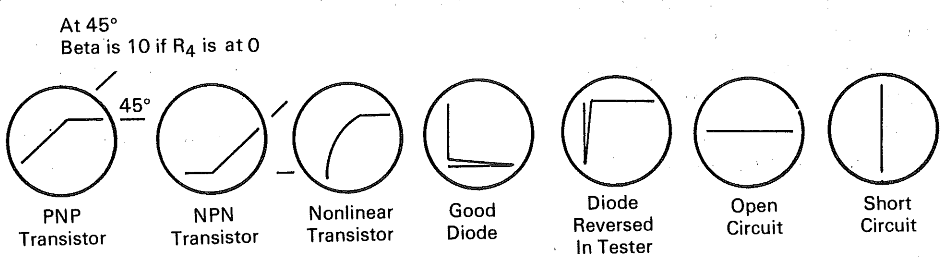
Category 01

November 1966 Brief 66-10447

NASA TECH BRIEF

Semiconductors Can be Tested Without Removing Them from Circuitry





The problem:

To devise a method of testing semiconductors without removing them from the circuitry. Prior art required that semiconductors be unsoldered from the circuit for checkout.

The solution:

An oscilloscope with specially developed test circuitry that can be used for a quick check of semiconductors while in a circuit. For transistors, approximate gain and linearity, as well as PNP or NPN determinations can be made. When testing diodes, open or short circuits, and reverse polarity show up plainly. The condition and the estimated breakdown voltage may be obtained on low voltage Zener diodes.

How it's done:

With a PNP transistor under test, the emitter has a positive voltage applied through R_1 and the collector is at a negative potential. Unless there is current flow in the base-emitter circuit, only a very small leakage current flows in the collector–emitter circuit. Whenever the alternate half-cycle makes the emitter positive, emitter–base current flows through R_3 and R_4 (R_3 is used for current limiting when R_4 is at zero). The current flow is measured as a voltage across R_3 and R_4 at the horizontal terminals of the oscilloscope, and is a measure of the transistor input current. Since the collector–emitter circuit is forward biased by B_1, it follows that when base current flows, collector current flows through R_1 This

(continued overleaf)

is the output current, which is read as a voltage at the vertical terminals of the oscilloscope. When the slope is 45°, it means that the input voltages are equal. The voltages are dependent on the current flow through resistors R_1, R_3, and R_4. If R_4 is set at zero to get a 45° slope, then there is 10 times the current flowing through the output resistor R_1 than flowing through the input resistor R_3 to make their voltage drops equal. The output current is 10 times the input current so the transistor has a beta (current gain) of 10. As the value of R_4 is increased to set the scope trace at 45°, the ratio of the output current to input current goes up. Using a numbered dial plate under R_4 knob, the approximate gain can be read. In calibrating, when switch S is closed, equal voltage appears across R_1 and R_2 thus giving equal deflection voltages across the scope horizontal and vertical inputs. (The scope sweep selector must be set to horizontal input or external sweep.) By proper adjustment of the scope vertical and horizontal gain controls, a sloping 45° line can be obtained on the screen. This sets the scope controls for equal gain on the vertical and horizontal channels.

When testing a low voltage Zener diode, the horizontal leg will break down at some distance out from the junction if the Zener is rated at less then 10 volts. Higher back resistance shows up on the trace as a downward slanting of the horizontal leg. With poor forward resistance, the vertical leg slants to the right. In-circuit testing will reveal the mentioned traces if the circuit resistance is more than the component under test; if not, the trace will vary by the degree of external circuit properties. When the printed circuit board has more than one identical circuit, it is a simple matter to compare these to find a bad component.

When testing a diode, apply 6.3 vac to the diode. The positive half-cycle forward biases the diode and the negative half-cycle reverse biases it. When the diode is conducting, it is the same as short circuiting the scope's horizontal terminal to ground and the full voltage will appear across R_1. The scope shows only a vertical line under these conditions. However, when the diode is not conducting, there is no current flowing through R_1 and therefore there is no vertical deflection, but full horizontal deflection. When the recurrent half-cycles are combined in the scope trace, the pattern is half vertical and half horizontal for a perfect diode. The poorer the diode, the less perfect is the pattern.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10447

Patent status:

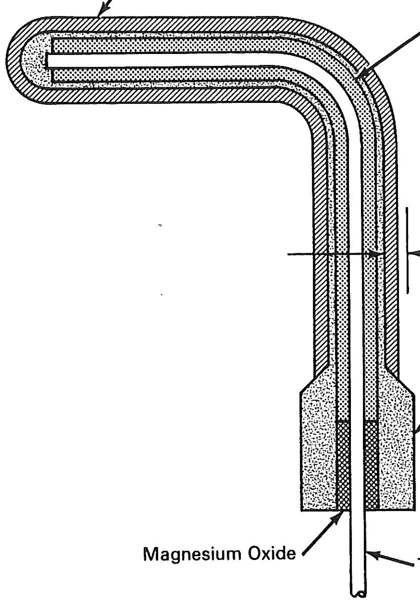
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Burdelle C. Allen
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1163)

November 1966 Brief 66-10461

NASA TECH BRIEF

Modified Thermocouple Is Effective From −250° to 5000° F



The problem:

To develop a thermocouple capable of continuous measurement in the range of −250° to 5000°F. It was necessary to measure the temperature of a spacecraft heat shield, and no commercially available thermocouple was satisfactory.

The solution:

A modified, commercially available thermocouple that has been made more sensitive, but will not disintegrate at the desired temperature.

How it's done:

Modify a commercially available thermcouple as follows:

(1) Chem-mil 0.004 inch off the tantalum sheath to make the thermocouple more sensitive.

(2) Coat the thermocouple with a thermally conductive ceramic coating that prevents disintegration at the desired temperature, but still permits the thermocouple to produce an output signal.

After modification, bend the thermocouple as required and fasten to the equipment under test.

(continued overleaf)

Notes:

1. There are many commercially available thermocouples that can easily be modified for use.
2. The modified thermocouples may be used inside metal treating furnaces, in high temperature technology, and in certain corrosive environments.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10461

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: W. K. Moen
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-420)

November 1966

Brief 66-10469

NASA TECH BRIEF

Bipolar Current Driver for Memory Circuits

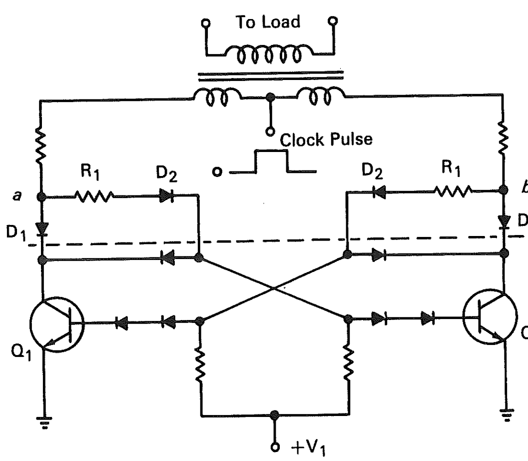


FIGURE 1

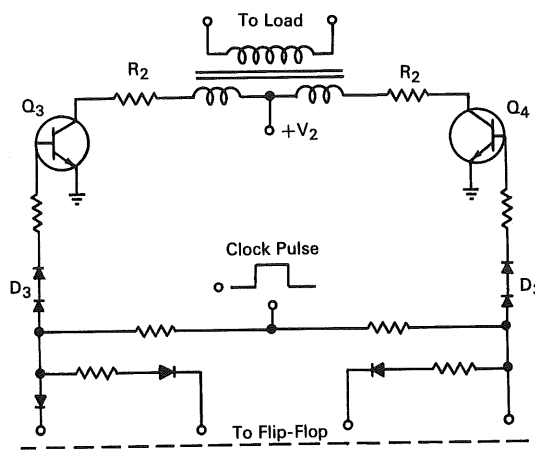


FIGURE 2

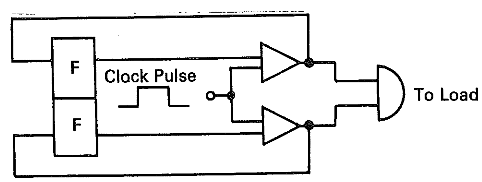


FIGURE 3

The problem:

To provide a bipolar driving current to a memory circuit, the polarity of which is determined by the state of a flip-flop. Ordinarily, the current flowing in the flip-flop is insufficient to act as a driving current since the logic circuit operates at a much lower level than is required for the driving circuit.

The solution:

A circuit which logically determines the state of a flip-flop and amplifies the current from a clock pulse flowing through the flip-flop by means of a feedback mechanism.

How it's done:

The circuit to be "read" is a standard low-current flip-flop, the portion below the dashed line in figure 1. Assume that Q_1 is conducting while Q_2 is nonconducting. With the clock pulse at ground potential, diodes D_1 and D_2 are back-biased and no current flows in the bit driver network (above the dashed line in figure 1). When a positive clock pulse is applied, the potential at node *b* increases far more than the potential at node *a* because transistor Q_1 remains in saturation. The potential at node *b* increases the forward bias of Q_1, allowing it to pass the additional current. Transistor Q_2 remains nonconducting since

(continued overleaf)

the small voltage at node *a* is insufficient to forward bias Q_2 in view of R_1 and the three diodes in the base connection. The current flowing from the clock pulse is transformer coupled to the load, and if Q_2 instead of Q_1 were conducting, a current of opposite polarity would be passed to the load. Thus the clock pulse supplies load current and steps up the operating level of the flip-flop. This circuit will provide sufficient driving current to the load if the clock pulse is of sufficient amplitude, and if the flip-flop is able to handle the additional current.

In cases in which the ratio of required load current to normal flip-flop current is very high (on the order of 10^4), a circuit such as that in figure 2 may be used. This circuit logically determines the state of the flip-flop as previously, but provides additional amplification through transistor Q_3 or Q_4. The resistors R_2 determine the collector current of the transistors, and diodes D_3 insure that either Q_3 or Q_4 will remain off.

Figure 3 illustrates the logic of operation of the circuits. The output of the "high" or "on" side of the flip-flop is amplified when the clock pulse is applied. Part of the amplified output is then fed back to the input of the flip-flop, thus increasing gain. The two outputs of the amplifiers are then appropriately connected to the load through transformer coupling.

Notes:

1. This principle may be applied to various memory driving circuits where power dissipation must be minimized.
2. One of the advantages of the type of driver illustrated in figure 1 is that fast rise times and short delays are obtained with ease because auxiliary amplifying components are not used.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10469

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: C. F. Chong and C. A. Nelson
of Sperry Rand Corporation
under contract to
Goddard Space Flight Center
(GSFC-213)

AEC-NASA TECH BRIEF

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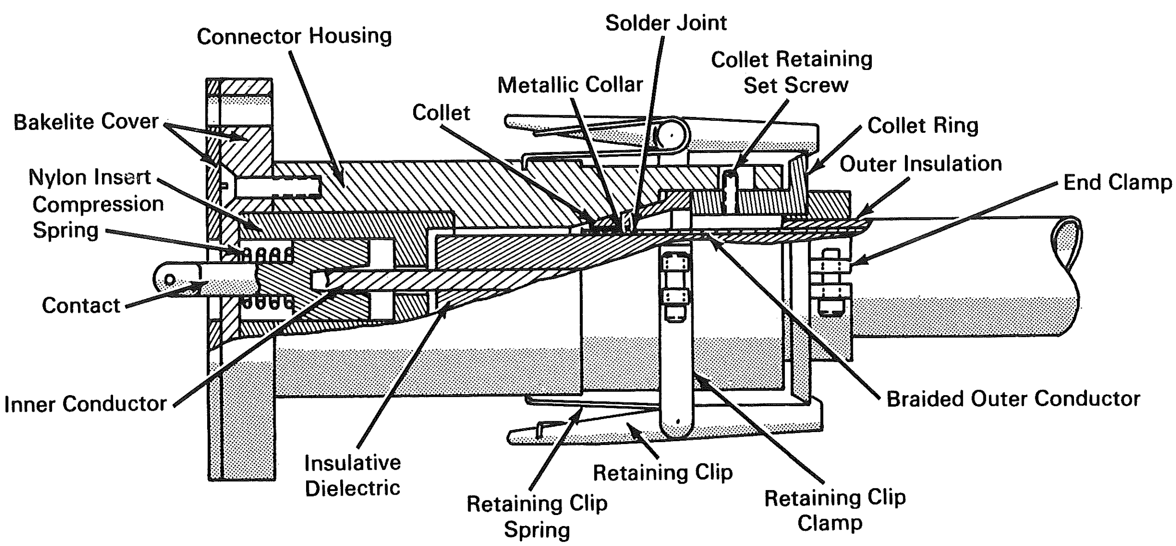
Plug-In Connector Socket Accepts Coaxial Cable End



The problem:

To design a connector which can be used as a receptacle for the end of a coaxial cable. The connector should hold the coaxial cable in place while making an electrical connection between an external contact and the inner conductor. It should be possible to remove and reinsert the cable with ease.

The solution:

A connector which includes a spring-loaded contact to receive the protruding center conductor and an internal collet to clamp against a collar attached to a woven outer conductor.

How it's done:

The connector is constructed of a cylindrical connector housing with a bakelite cover fastened to one end. A spring-loaded contact, which extends through a small hole in the bakelite, is mounted within a nylon insert near the bakelite covered end. Near the center of the housing is a collet with flexible fingers. The collet is held in place by a collet ring which fits inside the open end of the housing.

The end of the coaxial cable is cut and stripped so that each succeeding layer of material in the cable protrudes a specified distance out from the next outer layer. A metallic collar with an inside diameter just equal to the outside diameter of the insulative dielectric material of the cable is pushed over the dielectric until it butts against the braided outer conductor of the cable. The collar is then soldered securely to the outer conductor.

A clamp with two retaining clips is placed over one end of the housing. An end clamp is then placed over

(continued overleaf)

the coaxial cable. When the end of the coaxial cable is inserted into the connector, the inner conductor extends all the way into the spring-loaded contact and the collar lines up with the collet. The end clamp is then slid forward so that it butts against the collet ring. With this end clamp tightened securely to the cable, the cable end is pushed further into the connector, forcing the collet ring and collet inward, causing the collet to clamp against the collar. The compression spring allows the contact to move with the inner conductor.

The retaining clip clamp is moved so that the retaining clips will restrict any movement of the collet ring. The retaining clip clamp is then securely tightened, and small holes are drilled at the proper position to accept the retaining clip spring ends.

The coaxial cable is now held inside the connector. It can be removed simply by pressing the ends of the retaining clips free of the collet ring. The cable may be reinserted by pressing it into the connector until the retaining clips will fit over the collet ring flange.

Notes:

1. This plug-in connector socket has been used successfully with remote manipulators.
2. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 S. Cass Avenue
   Argonne, Illinois 60439
   Reference: B66-10478

Patent status:

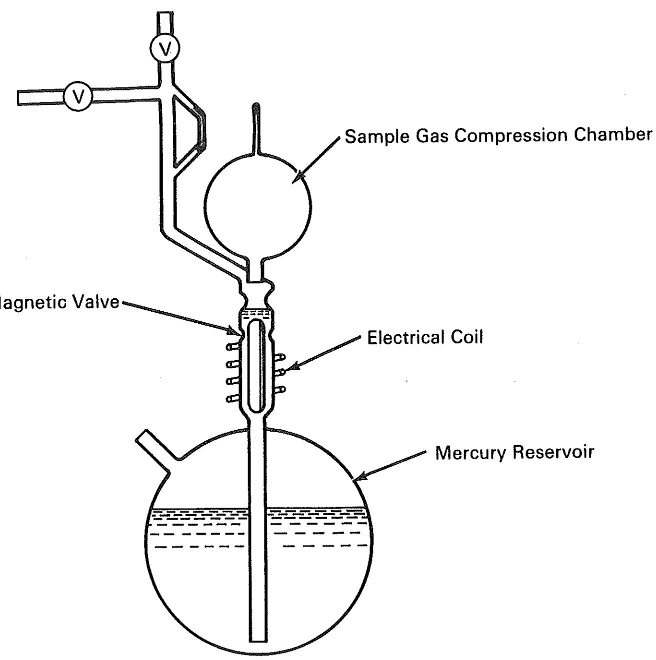
Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

Source: J. Van Loon and D. Mitchell
Chemistry Division
(ARG-9)

NASA TECH BRIEF

Modified McLeod Pressure Gage Eliminates Measurement Errors



The problem:

Conventional McLeod gages, which measure the absolute pressure of gases in the vacuum range, are subject to errors due to diffusion of mercury used in the gage. This is particularly a problem when a cold trap is used to prevent mercury vapor from getting into the system being measured; mercury vapor molecules streaming toward the cold trap "capture" molecules of the sample gas in a "pumping" action which results in an erroneous pressure reading. This error has previously been controlled by refrigerating the entire gage and by limiting the glass tubing size in order to limit the diffusion surface area of the mercury.

The solution:

Modify a conventional McLeod gage by introducing a valve between the mercury reservoir and the sample gas chamber. The valve isolates the mercury from the sample gas during equilibration, preventing the "pumping" action from taking place. It also opens the way for elimination of the cold trap. The valve is internal to the gage and is magnetically actuated, hence introduces no danger of leakage or contamination.

How it's done:

The conventional McLeod gage includes a reservoir containing mercury and a compression chamber of

(continued overleaf)

known volume positioned above the reservoir and connected to it by a passageway which permits the flow of mercury from the reservoir to the compression chamber and back again. A conduit from the system whose pressure is to be measured is connected to the passageway between the reservoir and the compression chamber.

The conventional McLeod gage is modified by the addition of a valve, containing a floating valve member, between the mercury and the compression chamber, which eliminates "pumping" error and the need for refrigeration. If suitable line valves are provided, the cold trap may be eliminated. The floating valve member is actuated magnetically through a coil or permanent magnet located on the outside of the McLeod gage, hence no danger of leakage or contamination exists. After equilibration, operation of the modified McLeod gage is identical with the conventional gage. The modified McLeod gage is illustrated.

To operate the McLeod gage, the level of the mercury is brought up to the neck of the passageway to a position just below the point of entrance to the upper compression chamber where the passageway opens to the conduit from the system whose pressure is to be measured. The magnetic valve is then closed, isolating the mercury surface from the system but leaving the sample gas free to travel into the compression chamber in the equilibration phase of the pressure measurement. When the pressure in the system and the pressure in the compression chamber are equal, the magnetic valve is opened and the level of the mercury raised, thereby cutting off the source of the pressure and compressing the gas in the compression chamber. The gas is compressed to a known volume at a known pressure, from which the pressure of the gas sample before compression can be calculated with the aid of Boyle's law.

Notes:

1. Several variations in operation of the valve are possible, including one based on the "cartesian diver" principle, which is nonmagnetic.
2. The McLeod gage modification does not increase the time required for pressure measurement or introduce the need for other corrections.
3. The modifications do not affect the volume stability of the gage.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10481

Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: Milton C. Kells
(ARC-62)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Solenoid Magnetic Fields Calculated from Superposed Semi-infinite Solenoids

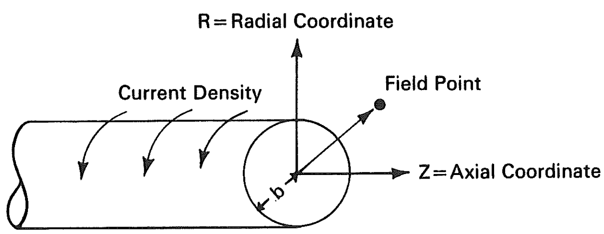


FIGURE 1

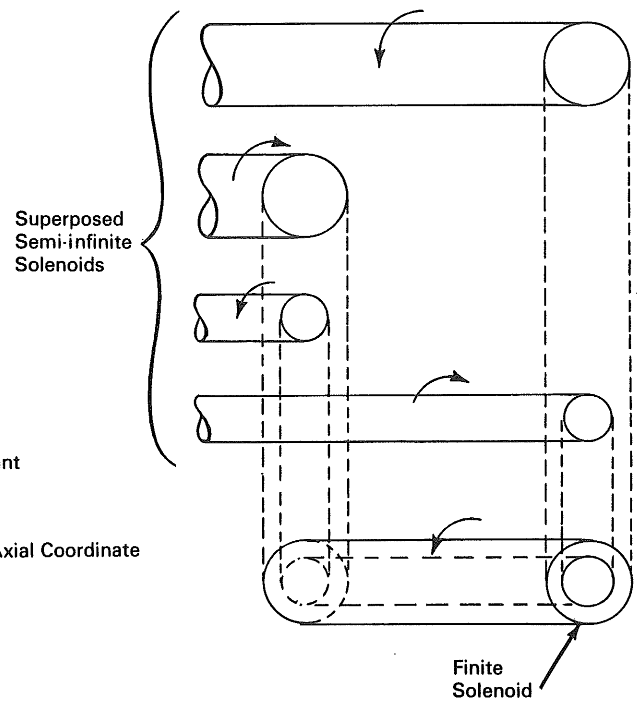


FIGURE 2

The problem:

The design of solenoid coils requires knowledge of the magnetic fields produced by a particular coil configuration. Field calculations are complicated by the effects of four variables: the radial and axial coordinates of the field point; the ratio of the solenoid's outer diameter to its inner diameter; and the ratio of the solenoid's length to its inner diameter. This variable complication also makes field component graphs or tables impractical because of the infinite tabulations required for all possible coil designs.

The solution:

A calculation of a thick solenoid's field components in terms of only two variables is made by a superposition of the fields produced by four solenoids of infinite length and zero inner radius (semi-infinite solenoids). The field produced by a semi-infinite solenoid is dependent on only two variables, the radial and axial

(continued overleaf)

field point coordinates expressed in terms of the solenoid's radius.

How it's done:

The semi-infinite solenoid of Figure 1 has an axially symmetric, uniform, azimuthal current density that extends from the axis of a cylindrical coordinate system to R equals b and from Z equals zero to Z equals infinity. Each field component of this semi-infinite solenoid can be expressed nondimensionally, computed electronically, and tabulated as a function of the nondimensional field-point coordinates where the radial equals R/b and the axial equals Z/b. The finite solenoid of Figure 2 can be considered a superposition of the four semi-infinite solenoids and its field can be obtained by adding four numbers derived from the tabulation.

Notes:

1. This innovation should be of interest to designers of field-producing solenoids.
2. Further information concerning this innovation is presented in NASA TN D-2494, "Superposition Calculation of Thick Solenoid Fields from Semi-infinite Solenoid Tables" by Gerald V. Brown and Lawrence Flax, September 1964, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151; price $1.25. Inquiries may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10490

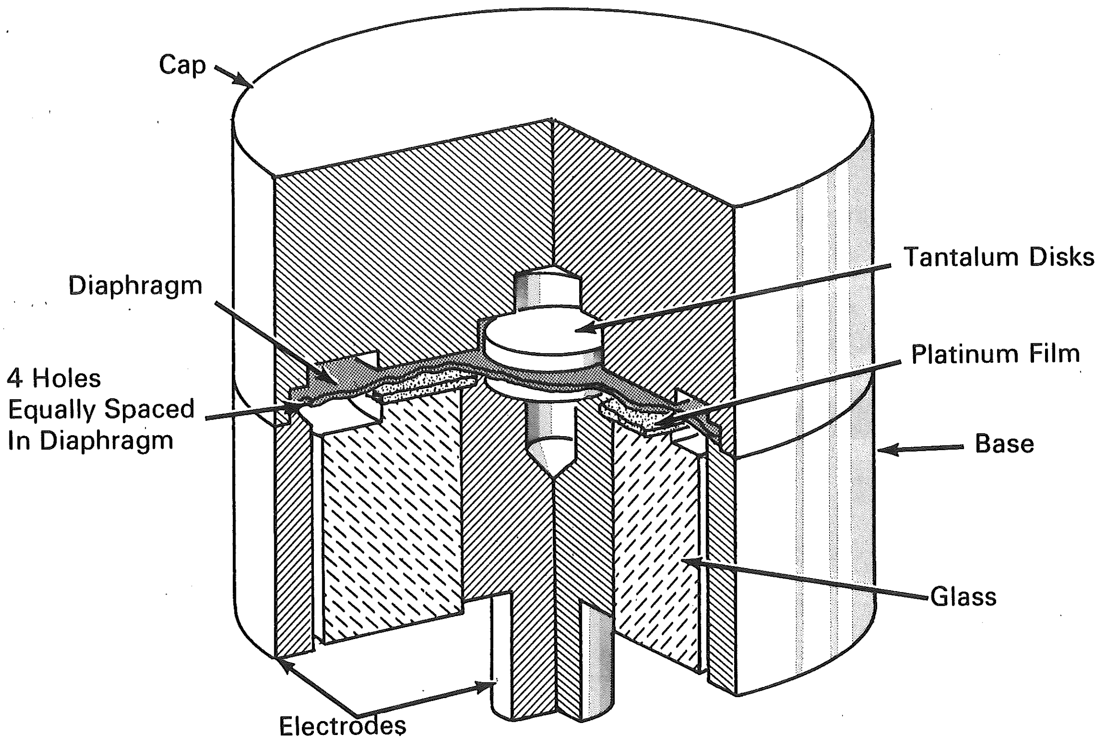
Patent status:

No patent action is contemplated by NASA.

Source: Gerald V. Brown and Lawrence Flax
(Lewis-184)

NASA TECH BRIEF

Miniature Capacitive Accelerometer Is Especially Applicable to Telemetry



The problem:

To design a class of miniature, general purpose accelerometers which are applicable to telemetry and which may be tailored to cover any of a large number of acceleration ranges and frequency responses. The accelerometers must be rugged, easily calibrated, inexpensive, and insensitive to temperature changes.

The solution:

A capacitive accelerometer design which enables the construction of highly miniaturized instruments having full-scale ranges from 1 g to several hundred g. Frequency responses are flat to 3 percent from 0 to 1000 cycles per second for the lower acceleration ranges and from 0 to 3000 cycles per second for the higher ranges. The accelerometers are 0.25 inch in diameter but have been constructed as small as 0.15 inch in diameter. Since the capacitive transducer modulates the "C" of the "L–C" circuit in the telemetry oscillator, the circuitry is extremely simple.

How its's done:

The capacitive accelerometer senses acceleration as a change in capacitance between a mass-diaphragm assembly and a platinized fixed electrode.

(continued overleaf)

The base of the accelerometer is machined from a commercially available glass–metal, single terminal, electrical feedthrough. A metal diaphragm with equal masses attached to the center of each side is welded at its periphery to the rim of the base. The diaphragm, with attached mass, functions as the variable plate of the capacitor. A metal cap soldered to the base completes the assembly. To provide vibration damping, atmospheric pressure is hermetically sealed inside the accelerometer. Pressure is equalized across the diaphragm by four small holes through the diaphragm.

The mass, spring constant, and required damping are provided in a minimum space. The mass consists of two thin, tantalum discs welded to the center of the stretched circular diaphragm. The prestressed diaphragm provides the spring restoring force. The damping is produced by the energy dissipation of the air set in motion by mass–diaphragm displacements. The frequency response can be controlled by varying the plate spacings and the size of the air sumps.

Notes:

1. These accelerometers have been successfully incorporated in a telemetry circuit for use with free-flight model instrumentation. Four channels were obtained by using four separate telemeter units, each operating at a different frequency and working into a separate receiver. Standard fm telemetry receivers were used to acquire the data.
2. The capacitive accelerometer has proved to be rugged, applicable to low or high g measurements, easily calibrated, and of adequate linearity and frequency response.
3. This capacitive accelerometer is similar to a capacitive pressure cell described in NASA Tech Brief B63-10429, "Welded Pressure Transducer Made as Small as 1/8-inch in Diameter," March 1964.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10491

Patent status:

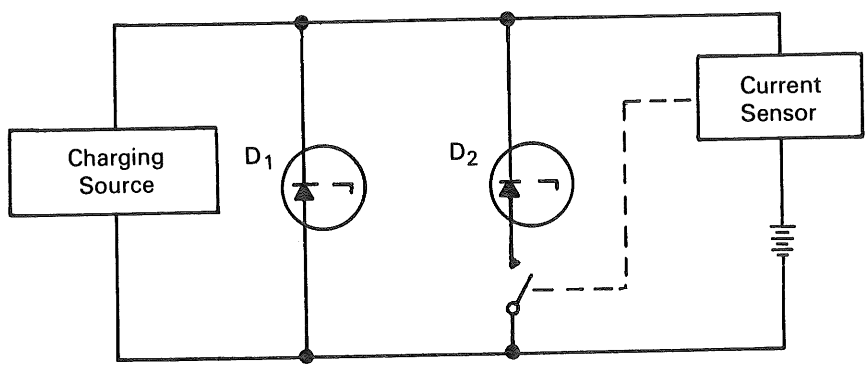
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: G. W. Coon and D. R. Harrison
(ARC-72)

November 1966 Brief 66-10492

NASA TECH BRIEF

Circuit Prevents Overcharging of Secondary Cell Batteries



The problem:

To design a circuit that will prevent any cell, such as a sealed silver–cadmium or silver–zinc cell, in a series battery from overcharging, with consequent internal gas buildup. The resulting pressure can cause a sealed cell to leak electrolyte and thereby lead to failure of the entire battery.

While it is relatively simple to limit the charging voltage on a single cell, it is difficult to limit the charging voltage on each cell of a number connected in series. When charging voltage is applied to a battery, varying potential differences will occur across the individual cells. This cell unbalance may lead to overcharging of one or more cells of a series. Systems which have attempted to solve this problem by first charging at a high current and then at a trickle rate have not been entirely satisfactory. These systems only allow a longer time before overcharging can occur.

The solution:

A circuit that detects the battery charging current and reduces the charging voltage to the open-circuit voltage of the battery when this current falls to a predetermined value. The voltage control depends on the experimentally observed fact that the charging current falls significantly when the battery nears its fully charged state.

How it's done:

The circuit includes a current sensor connected in series with the battery to be charged and a voltage regulator connected in parallel with this series combination. The regulator consists of two parallel-connected zener diodes, D_1 and D_2. Diode D_2, which has a lower breakdown voltage than D_1, is connected in series with a switch.

In operation, the charging source applies a voltage at the breakdown value of D_1. As the battery approaches its fully charged state, the current drops. The current sensor detects this current drop and closes the switch. This closure provides a parallel path through D_2. The breakdown voltage of D_2 is chosen so as to maintain the battery at its open-circuit value. Hence, this second path drops the applied voltage and thereby prevents the overcharge of the battery.

(continued overleaf)

Notes:

1. Various types of current sensor and voltage regulator can be used to prevent overcharging of a battery of secondary cells in accordance with the principle of dropping the charging voltage when the charging current falls to a predetermined value.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10492

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Thomas J. Hennigan, Nelson H. Potter, and Kenneth O. Sizemore
(GSFC-454)

November 1966 Brief 66-10493

NASA TECH BRIEF

Study Shows Effect of Surface Preparations on Improving Thermionic Emission

Specimen thermionic emitters were electropolished and electroetched as part of a program to study the effect of surface preparations on improving thermionic emission.

It was known that the best thermionic emission is achieved from the (110) plane of tungsten, and that these planes have the highest atomic density. It was also known that the highest atomic density in the rhenium lattice was found on the basal planes. Therefore, techniques were investigated which would maximize the amount of basal plane on the surface of a polycrystalline rhenium emitter. The best technique found was to electropolish the annealed rhenium surface and then electroetch it. Both operations were performed in an electrolyte consisting of:

175 ml Butanol
175 ml Methanol
175 ml Perchloric Acid (density 1.54)
50 ml Ethylene Glycol Monobutyl Ether

Electropolishing was carried out at about 30 volts, and electroetching at about 5 volts, with the specimen as anode. The effect of electroetching was to remove other crystal planes faster than basal planes, and thus maximize the amount of basal plane on the specimen surface.

The electroetching resulted in roughening of the electropolished surface; however, the increase in thermionic emission was greater than could plausibly be accounted for in terms of the increased area of the emitter surface.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10493

Patent status:

No patent action is contemplated by NASA.

Source: Lawrence van Someren
of Thermo Electro Engineering Corp.
under contract to
Jet Propulsion Laboratory
(JPL-SC-140)

Category 01

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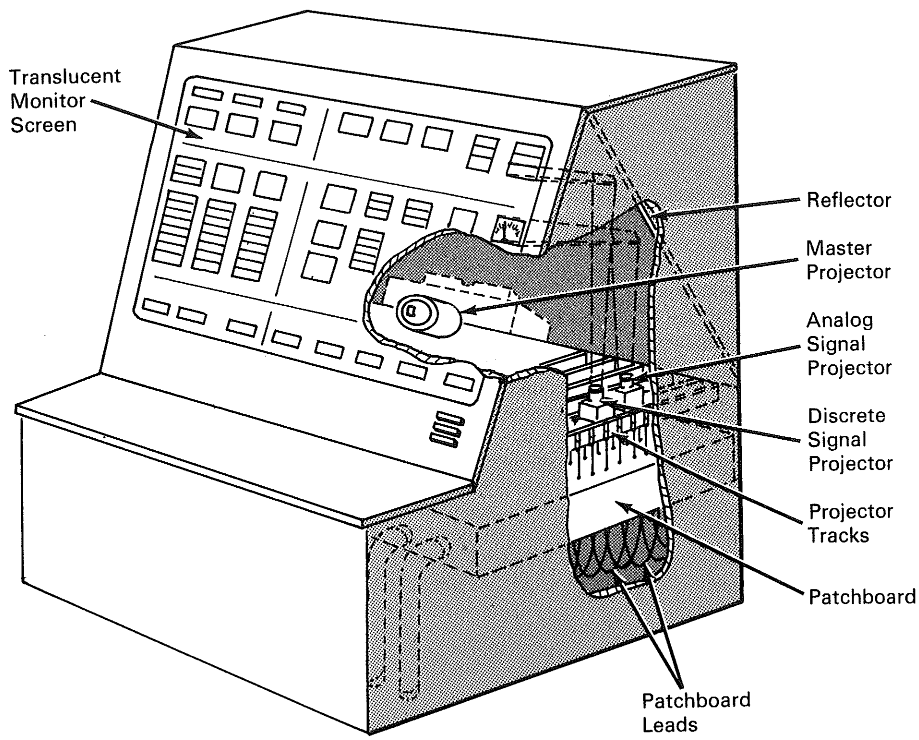
NASA TECH BRIEF

Optical Monitor Panel Provides Flexible Test Panel Configurations



The problem:

To develop a multipurpose monitor panel that can be easily configured for various test monitoring objectives, especially in rapidly changing test programs. Present panels are fabricated from sheet metal or other permanent materials and require sheet metal work, engraving, and installation of monitor indicators. Such panels are inflexible, and they are expensive to fabricate or modify.

The solution:

An optical monitor panel that projects a chosen panel configuration upon a translucent screen by using a master projector and appropriate slide to project panelboard nomenclature and a series of

(continued overleaf)

smaller individual projectors to superimpose monitor indicators upon the projected panel board.

How it's done:

In operation, a slide of the panel layout is inserted in the master projector and projected on the translucent monitor screen. Monitor projectors are clipped onto the projector tracks at locations indicated by the panel layout. Electrical power and the signals to be monitored are patched into the patchboard, and the patchboard leads are electrically connected to the monitor projectors. After a press-to-test circuit confirms that all components are working and correctly located, the panel is ready for use. Monitor projector images are projected on the screen by the reflector.

Two types of monitor projectors are used, the analog signal projector and the discrete signal projector. Each analog signal projector has a meter with a transparent face so light can be projected through it. Each discrete signal projector has a slide carrier which accommodates a colored slide. The discrete signal projector is used for colored light indications, such as "28 VDC ON" or "SYSTEM READY" lights. The projectors clip onto the track at the conductive segments, which are separated by insulation. Power and signal voltage for the projection lamps and meters are received from the conductive segments.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Kennedy Space Center
Kennedy Space Center, Florida 32899
Reference: B66-10494

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Francis D. Griffin
(KSC-66-18)

November 1966

Brief 66-10496

NASA TECH BRIEF

Computer Program Performs Flow Analysis Through Turbines

The problem:

To devise a method of analyzing flow through a turbomachine (turbine, compressor, or pump) that is readily adaptable to computer programming. Previous methods obtained a two-dimensional solution based on an equation for the velocity gradient along the normal to the projection of the streamlines on a plane containing the axis of rotation (the meridional plane). The meridional streamlines and their normals are used to establish a grid for a meridional-plane solution. In cases where the distance between the hub and shroud is great and there is a large change in flow direction within the rotor, the normals vary considerably in length and in direction during the course of the calculations. Therefore, it is difficult to obtain a direct solution on the computer without resorting to intermediate graphical steps.

The solution:

A new method and computer program based on an equation for the velocity gradient along an arbitrary quasi-orthogonal rather than the normal to the streamline as used in previous methods. The program (in the Fortran programming language) obtains meridional solutions for a hub-to-shroud analysis and blade-to-blade analysis at the hub, mean, and shroud surfaces in a single computer run.

How it's done:

This method obtains a direct solution by the use of arbitrary curves (called quasi-orthogonals) from hub to shroud instead of streamline normals. The quasi-orthogonals are not necessarily orthogonal to each streamline but intersect every streamline once across the width of the passage. The quasi-orthogonals remain fixed regardless of any change in streamlines. Using this technique, a computer program is developed that calculates a streamline solution in the meridional plane without any intermediate graphical procedures, even for turbomachines with wide passages and a change in direction from radial to axial within the rotor blade.

From the meridional solution, it is possible to obtain blade-surface velocities by several methods. However, the basic concept used to obtain the meridional solution can also be applied to obtain a blade-to-blade solution. In this case, the quasi-orthogonals run from blade to blade on a stream surface determined by the meridional solution. By extending the solution upstream and downstream, a good solution throughout the rotor is obtained.

Notes:

1. This program will be useful in the design of any type of turbomachines (turbines, compressors, or pumps) and for either compressible or incompressible fluids.
2. Further information concerning this innovation is presented in NASA TN D-2546, "Use of Arbitrary Quasi-Orthogonals for Calculating Flow Distribution in the Meridional Plane of a Turbomachine" by Theodore Katsanis, December 1964; and in TN D-2809, "Use of Arbitrary Quasi-Orthogonals for Calculating Flow Distribution on a Blade-to-Blade Surface in a Turbomachine" by Theodore Katsanis, May 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Inquiries may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10496

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

Source: Theodore Katsanis
Lewis Research Center
(Lewis-236)

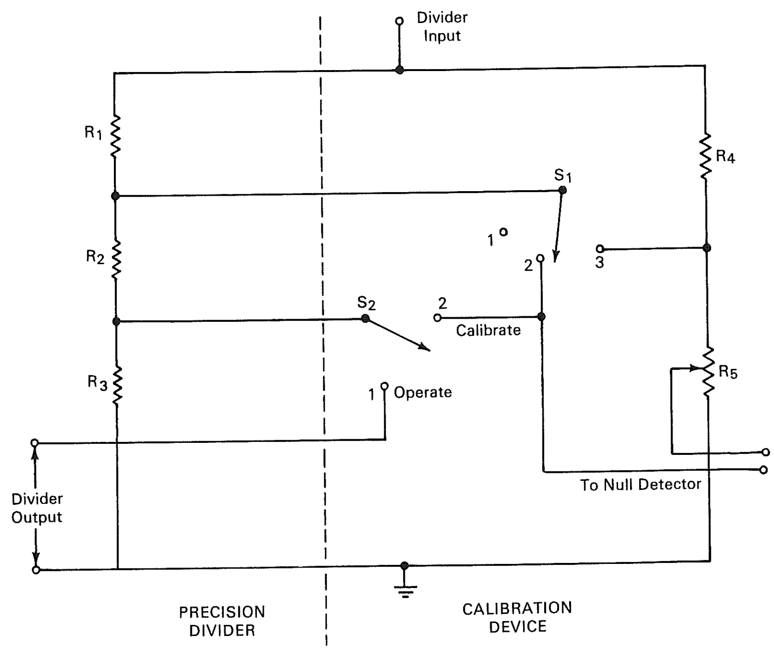
November 1966

Brief 66-10497

AEC-NASA TECH BRIEF

AEC-NASA Tech Briefs describe innovations resulting from the research and development program of the U.S. AEC or from AEC-NASA interagency efforts. They are issued to encourage commercial application. Tech Briefs are published by NASA and may be purchased, at 15 cents each, from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

High Voltage Potential Divider Calibrated by Simple Device



The problem:

To obtain fast, accurate, in-circuit calibration of a high potential divider while it is operated under normal current and voltage conditions. Since the divider resistance varies with applied voltage at potentials over 1000 volts, high potential dividers must be calibrated at their operating voltage for accurate results. Standard low voltage laboratory calibration equipment is unsuitable for this application.

The solution:

A resistance bridge device that incorporates a potentiometer, switches, and a null detector to calibrate high potential dividers under high voltage operation conditions.

How it's done:

Resistors R_1, R_2, and R_3 make up the potential divider to be calibrated. The calibration device is made up of resistor R_4, which can be a low precision resistor capable of supporting the applied operating voltage; resistor R_5, a high precision potentiometer; switches S_1 and S_2; and a null detector.

To calibrate a high potential divider, the divider input is applied to the input terminals of the calibration circuit, switch S_2 is moved to the "calibrate" position, switch S_1 is moved to position 1 and potentiometer R_5 is adjusted until a null is obtained on the null detector. The same procedure is followed for positions 2 and 3 of switch S_1 and the 3 resulting potentiometer readings (P_1, P_2, P_3) of R_5 at the nulls

(continued overleaf)

are recorded. These 3 values are then used in the equation:

$$\frac{E_{out}}{E_{in}} = \frac{R_3}{R_1+R_2+R_3} = \frac{P_2-P_1}{P_2} \times \frac{P_3}{1-P_3}$$

to completely specify the resistance ratio of the high-potential divider.

Notes:

1. Calibration can be performed with this device in less than 1 minute at an accuracy of 0.001 percent.
2. Additional information is contained in *Rev. Sci. Instr.,* vol. 36, no. 4, pp. 532–537 (April 1965).
3. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 S. Cass Avenue
   Argonne, Illinois 60439
   Reference: B66-10497

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

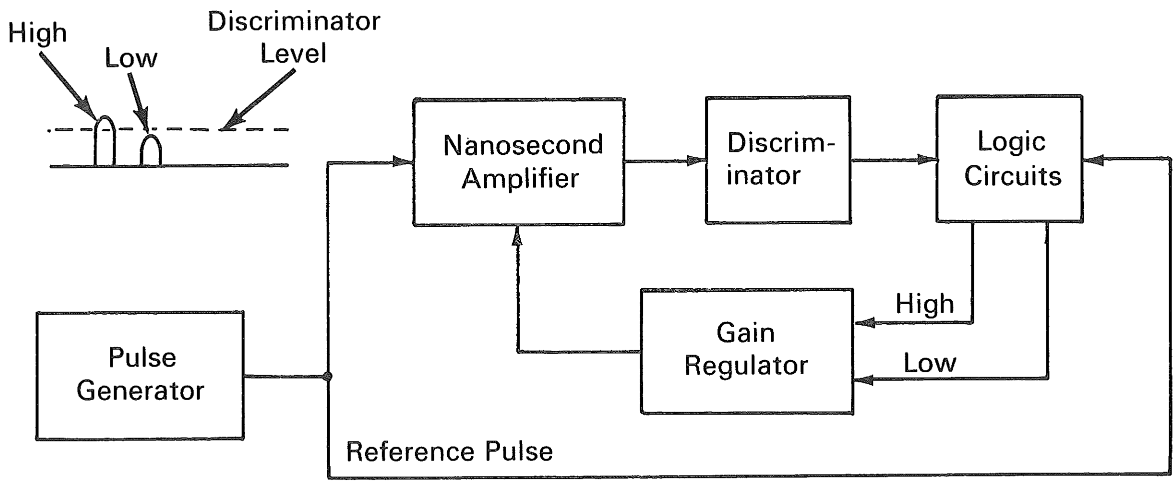
Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

Source: R. N. Lewis
Electronics Division
(ARG-83)

AEC-NASA TECH BRIEF

AEC-NASA Tech Briefs describe innovations resulting from the research and development program of the U.S. AEC or from AEC-NASA interagency efforts. They are issued to encourage commercial application. Tech Briefs are published by NASA and may be purchased, at 15 cents each, from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Digital System Provides Superregulation of Nanosecond Amplifier–Discriminator Circuit



The problem:

To provide stable gain characteristics for nanosecond amplifiers used in counting applications.

The solution:

A feedback system employing a digital logic comparator to detect and correct amplifier drift.

How it's done:

The amplifier-regulator system consists of a pulse generator, logic circuits, discriminator, and a gain regulator. The pulse generator supplies alternately high- and low-amplitude pulses. The amplitude of the low pulse is just below the level of the disciminator and will not normally pass through the discriminator. The amplitude of the high pulse is just above the level of the discriminator and will normally pass through it.

These pulses are fed to the input of the amplifier and the logic circuits. The output of the disciminator is fed to the input of the logic circuits. The logic circuits consist of splitter circuits, coincidence circuits, and anticoincidence circuits.

When a low pulse is generated, a reference pulse is sent to a coincidence logic circuit. If the gain of the amplifier is correct, there will be no corresponding low-amplitude pulse from the discriminator and no output from the coincidence circuit. When a high pulse is generated, a reference pulse is sent to an anticoincidence logic circuit. If the amplifier gain is correct, the discriminator will pass the pulse and no output will come from the anticoincidence circuit. If the gain of the amplifier increases, the discriminator will pass the low-amplitude pulses and a signal will result from the coincidence circuit. If the gain of the amplifier decreases, the high-amplitude pulses will be blocked by the discriminator and a signal will result from the anticoincidence circuit. The high and low

(continued overleaf)

outputs from the logic circuits, corresponding to increases and decreases in amplifier gain, are fed to a gain regulator which corrects the gain of the amplifier appropriately.

Notes:

1. By employing additional anticoincidence logic, the regulation circuit may be applied to the amplifier and discriminator while they are mounted in an operable circuit, so that long term continuous regulation may be achieved.
2. By employing the digital logic comparator system, gain excursions can be held within the amplifier noise width, typically 40-60 microvolts to input of amplifiers of 100 MHz bandwidth. In addition, the reference pulses are held to a few microvolts per week drift.
3. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 S. Cass Avenue
   Argonne, Illinois 60439
   Reference: B66-10500

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. Geoge H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

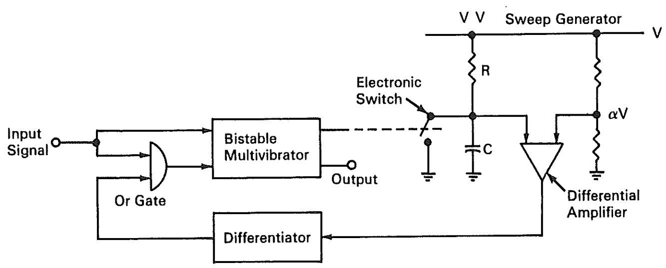
Source: K. G. Forges
Reactor Engineering Division
(ARG-61)

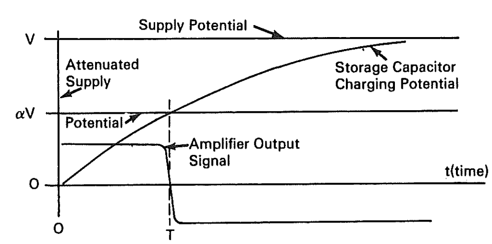
November 1966

Brief 66-10501

NASA TECH BRIEF

Electronic Circuit Delivers Pulse of High Interval Stability





The problem:

In a number of electronic instrumentation systems, accurate counting of events per unit time requires a pulse of specified and highly stable interval. Such systems have been designed in the past but, generally, at a very high complexity level.

The solution:

A circuit that fundamentally depends, for its stability, on the regularity of an energy storage–energy dissipative time constant. This circuit generates a pulse of high interval stability with a complexity level considerably below systems of comparable stability.

How it's done:

An input pulse of either random or predetermined period triggers the bistable multivibrator. With the multivibrator in the reset state, this pulse drives it to the set state and its true output drives the switch to the open or nonconducting state. This causes the capacitor terminal potential to increase toward the supply potential (V). The high gain and wide bandwidth differential amplifier now generates a single-ended output voltage in response to the capacitor instantaneous potential as well as to the fixed potential V, the algebraic difference between the two representing the amplifier input signal.

Assuming that the capacitor is allowed to charge indefinitely, the differential amplifier output signal would appear as shown in the figure on the right. At the instant denoted T, the differential input signal changes relative polarity, that is, the attenuated potential V is greater than the capacitor potential before time T, whereas after time T the converse is true. This in turn causes the amplifier output potential to rapidly reverse potential at T in a period dependent on the gain and bandwidth of the amplifier.

The interval T is solely dependent on the supply potential V if the capacitor is initially charged $V_C(0)$ so that proper circuit operation depends on the capacitor being fully discharged before each triggering event. This requirement effectively sets an upper limit to the frequency of operation, being related to the choice of capacitance of the RC time constant for a given application.

Output of the differentiator resets the bistable multivibrator at a precise preselected instant and the output of the multivibrator drives the switch to the closed or conducting state to discharge the capacitor, which in time returns to its quiescent state. The circuit remains in the discharged state until the next input triggers the bistable multivibrator to repeat the events described above.

(continued overleaf)

Notes:

1. This circuit is being used as a linear frequency discriminator in the signal conditioner of the Apollo comand module.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10501

Patent status:

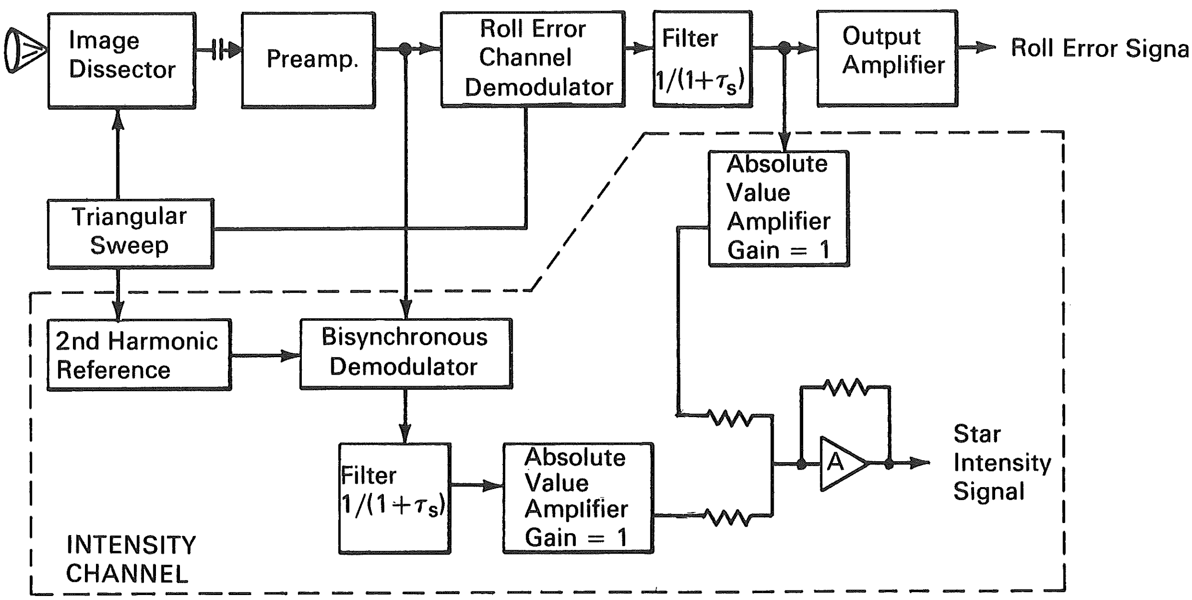
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Benjamin Fisher
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-673)

November 1966 Brief 66-10502

NASA TECH BRIEF

Point-Source Light Sensor Circuit Is Insensitive to Background Light



The problem:

To devise a circuit for an electro-optical star-tracking sensor that will provide a signal proportional to star intensity without interference from background light in the field of view. Conventional star sensors use a peak detector, which introduces a relatively large noise signal resulting from peak detection of the background light.

The solution:

A circuit incorporating a bisynchronous demodulator which extracts intensity information from the modulated signal in an electro-optical position sensor.

How it's done:

A thin slice of the sky, approximately 4 degrees by 32 degrees, is focused by an optical system upon the photocathode of the image dissector. The electron space-charge analog of the optical image is transmitted toward an elongated vertical aperture at the far end of the image dissector. The electron analog is moved laterally in synchronism with a triangular sweep signal past this aperture. The output of the image dissector is then amplified in the preamplifier. The raw signal, as well as the sweep signal and the second harmonic reference, then goes to the two demodulators. Both demodulators are amplitude- and phase-sensitive, that is, have an output which varies depending on the amplitude and phase of the detected signal from the star with respect to the sweep voltage. The signal from the roll error channel demodulator, after being filtered and amplified, is the required roll error signal.

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Bisynchronous demodulation is utilized in the intensity channel. Basic to bisynchronous demodulation is the first harmonic reference signal, which has a frequency twice that of the sweep signal and a phase-shift lead of 90 degrees. The raw signal is demodulated and filtered as in the roll channel. The absolute values of the outputs from both demodulators are then summed to give a voltage which is exactly proportional to the average anode current and the star intensity, independent of the position of the star in the field of view.

Notes:

1. The system works best on a sharply focused star image and requires a 50 percent duty cycle.
2. This circuit can be advantageously used for extracting intensity information from any electro-optical position sensor or photometer where background noise presents a problem.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10502

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Edgar S. Davis
(JPL-778)

NASA TECH BRIEF

Computer Program Determines Performance Efficiency of Remote Measuring Systems

The problem:

To develop a procedure for control and evaluation of instrumentation system performance for numerous rocket engine test facilities and to prescribe calibration and maintenance techniques to maintain the systems within process specifications.

The solution:

A set of computer programs for rapidly processing measurement system calibration data. The input is a set of measurements of transducer responses, and the output is a listing of all transducer calibration states in the system or the test stand. The results indicate quantitative measures of instrument performance. Corrective action is recommended when necessary.

How it's done:

The Measurement Systems Analysis (MSA) program consists of a series of digital computer programs that prescribe calibration and maintenance for the following measurement systems:

1. Thrust (force)
2. Pressure
3. Temperature
4. Flow rate
5. Vibration
6. Current and voltage

The MSA program combines automated "inventory-type" control with modern statistical techniques to provide easily assessable information attesting to the status of thousands of measuring systems. The program output listing or "roadmap" is a comprehensive report of the status of each of the measuring systems (about 40) at each respective test stand.

An MSA program can be used on a typical pressure measurement in the following manner: (1) transducer is subjected to periodic laboratory calibrations per specification, (2) precision of the transducer is calculated by a computer program, (3) original measurement system is resynthesized, (4) recording element is calibrated and precision obtained by automatic data processing, (5) computer program appropriately combines the precisions of the system elements for a system precision, (6) MSA roadmap apprises test personnel of the precision of their pressure measuring system, and (7) test personnel can now decide, in light of customer requirements, whether the system is excessively error prone. Corrective action is taken for "out-of-precision" systems.

Notes:

1. Similar programs can be written for other test equipment in an industry such as the petrochemical industry.
2. The detailed calibration, maintenance, and statistical techniques for the various pressure, thrust, and temperature measuring systems can be used by many organizations toward establishment of methods for measurement in a standard calibration analysis laboratory.
3. Inquiries concerning this innovation may be directed to: Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10503

Patent status:

No patent action is contemplated by NASA.

Source: E. K. Merewether
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1137)
Category 01

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Subroutine Allows Easy Computation in Extended Precision Arithmetic

The problem:

To devise a program that allows relatively simple computation of very large numbers or very small fractions with extreme accuracy. Ordinary double precision FORTRAN arithmetic is limited to numbers between 10^{-38} and 10^{+38}, and to 16 digits of accuracy.

The solution:

A subroutine called NPREC that can perform mathematical operations in extended precision floating point arithmetic. This subroutine handles numbers that consist of 35 binary bits (1 word) for the exponent and 70 bits (2 words) for the fraction. A programmer can perform a variety of mathematical operations by writing standard FORTRAN statements within the NPREC routine instead of calling a separate routine to perform each operation.

How it's done:

NPREC can be used on any of the IBM 709/7090/7094 computers. A statement, CALL NPREC, is used to enter the routine and subsequent statements are interpreted by the routine until the exit statement, CALL NPOUT, is encountered. Any statement that is interpreted in NPREC will take longer to execute than if it were executed outside of the routine, and thus all normal single or double precision statements should be executed outside of the routine.

The NPREC routine incorporates subroutines in converting to and from extended precision numbers and also includes the following extended precision elementary functions: square root, sine, cosine, arc tangent, natural log, and exponential. The only "built-in" library functions that may be used in NPREC are ABSF, MAX1F, MIN1F, AND SIGNF. There is limited use of FORTRAN exponential notation in NPREC; and extended precision numbers may be raised to a fixed point power of 2, 3, 4, 5, or 6 only. Any other type of exponential operation must be performed using the exponential and natural log routines within NPREC. No more than 15 operations should appear in any single statement in NPREC.

The NPREC routine will detect 20 errors. When one of these errors is detected, a comment will be written in 1 of 2 formats on output tape 6, after which a core dump is given and the job is finished.

The time it takes to perform an arithmetic operation in NPREC varies with the values and relative values of the operands, and also depends on whether or not the operands are stored in COMMON. As an indication of the time requirements, an extended precision division takes approximately 1.4 milliseconds on the 7090 and a multiplication approximately 0.6 milliseconds. The natural log and exponential functions require approximately 36 and 48 milliseconds respectively. Multiplying the 7090 time by 6 gives the 709 time.

NPREC and its associated subprograms require 2053 storage locations.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10504

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

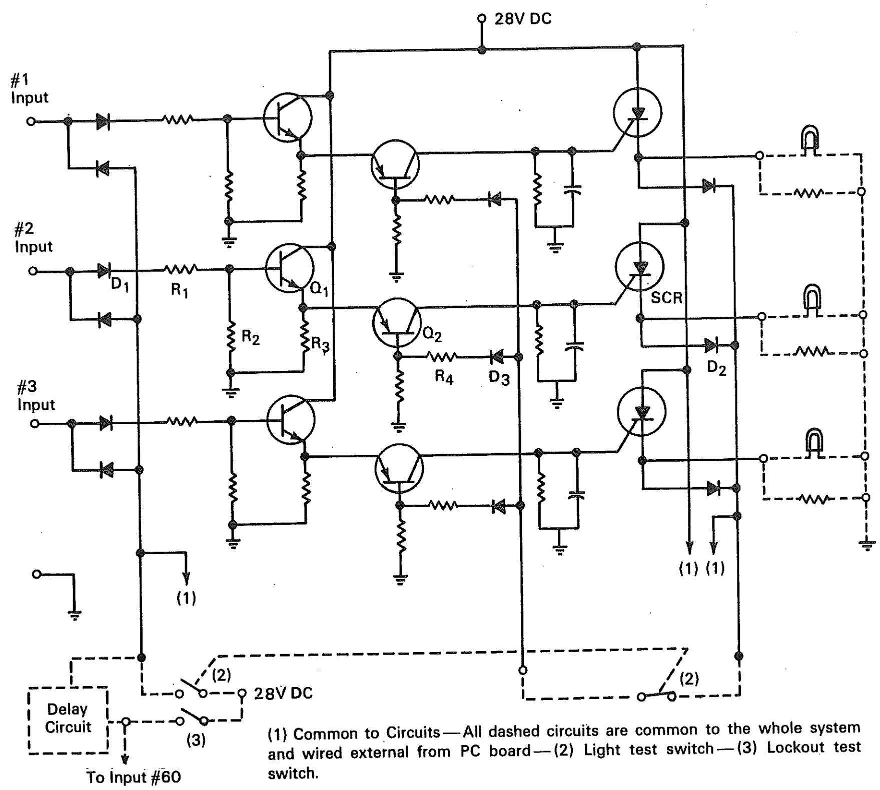
Source: R. L. Berggren and J. C. Gysbers
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1136)

November 1966

Brief 66-10505

NASA TECH BRIEF

Solid State Annunciator Facilitates Complex System Troubleshooting



(1) Common to Circuits—All dashed circuits are common to the whole system and wired external from PC board—(2) Light test switch—(3) Lockout test switch.

The problem:

In the testing of complex systems, an indication of the first incoming cut signal terminating a test is required in order to troubleshoot the cause of termination. Presently used equipment is too slow and does not monitor sufficient parameters to indicate the initial cause of a test shutdown.

The solution:

A solid state annunciator that monitors up to 60 parameters for a dc voltage change from zero to 28 volts.

How it's done:

Three typical channels and associated circuitry are shown although discussion is limited to the operation of one because all are identical. Assuming all inputs at zero potential and the unit reset, a 28 vdc signal is applied to the number 2 input. Diode D_1 passes the signal to the voltage divider R_1, R_2, thus applying a positive potential to the base of Q_1, causing it to conduct. Q_1 establishes a threshold against noise, which could otherwise cause false response. The output from Q_1 is developed across R_3 and applied to the emitter of Q_2, which will conduct as long as its

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base is not biased for cutoff. From the collector of Q_2 the signal is applied to the gate of the SCR causing it to conduct. The 28 vdc at the cathode of the SCR performs 2 functions: it lights the lamp to indicate the channel associated with the first malfunctioning test component; it also applies the 28 vdc to a bus, through D_2, that feeds back to the bases of all Q_2 transistors through all D_3 diodes and R_4 resistors to lock out all other SCR rectifiers.

A light test circuit (2) checks for proper operation of all channels by interrupting the feedback from the SCR cathodes to the Q_2 bases and simultaneously applying a 28 vdc signal to all inputs. A lockout test circuit (3) applies a 28 vdc signal to only 1 input and after a 10–20 microsecond delay, to all other inputs. If the system is functioning properly, only the lamp associated with the first input energized will light.

Notes:

1. This annunciator is presently being used for testing of the complex J-2 rocket engine.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10505

Patent status:

No patent action is contemplated by NASA.

Source: H. P. Hofer
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1258)

November 1966 Brief 66-10506

NASA TECH BRIEF

Computer Program Determines Inventory Size

The problem:

To determine the optimum size of a small inventory of relatively complex or expensive items.

The solution:

A FORTRAN IV computer program that calculates the optimum initial inventory size in a problem based on minimum costs for the assumed model of inventory behavior, and within the restraints of relevant cost and time factors specified by the user, for the specific problem.

How it's done:

The program is based on a model that assumes a small replenishable inventory of expensive items that are withdrawn according to a Poisson distribution with some known average rate. Withdrawal of an item from inventory creates an immediate reorder, and delivery time intervals are assumed to be exponentially distributed. Queues are not considered in the model; that is, service is instantaneous and requests for unavailable items are cancelled immediately.

The inventory control program is also particularly applicable to damageable and repairable items. In this situation the number of items that fail in a given time interval is assumed to be Poisson distributed and the repair or replacement times are exponentially distributed.

The cost function for controlling this type of inventory balances the cost of acquiring items that may never be used against the cost, due to unfilled demands. The optimum initial stock size is determined by the minimization of total costs in this balance. This is established on the basis of a solution of differential equations for the first and second moment of the inventory-size distribution.

The computer program that performs this optimization is written in FORTRAN IV and is limited to inventories of size 40. The required input parameters to the program are the failure or withdrawal rates, replenishing rate, cost factors, and the time interval over which the inventory is to be controlled.

Notes:

1. This program can be used in situations where the initial cost of purchase is large, when there is a need for a balanced inventory, on a short production run, or in a similar situation where there is a relatively small inventory of expensive or complex parts.
2. Inquiries concerning this innovation may be directed to:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10506

Patent status:

No patent action is contemplated by NASA.

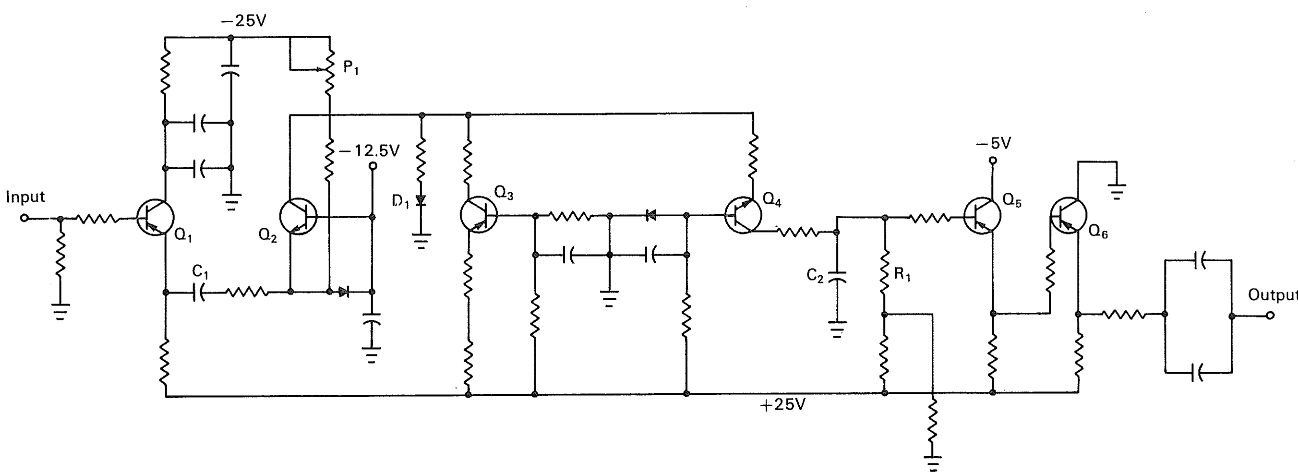
Source: Hans Kaspar
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1135)

Category 01

November 1966 Brief 66-10509

AEC-NASA TECH BRIEF

Pulse Stretcher Has Improved Dynamic Range and Linearity



The problem:

To lengthen nanosecond pulses so that their amplitude may be determined and to extend the dynamic range of the pulse stretcher. The most serious limitation of the commonly used diode–capacitor stretcher is the nonlinear attenuation of the diode for signals of less than a few hundred millivolts. Also, when operating in the nanosecond range the diode capacitance allows partial feedthrough of the signal to produce distortion.

The solution:

A current-switching pulse stretcher to overcome the diode nonlinearity and capacitive feedthrough of voltage switching diode–capacitor stretchers.

How it's done:

The figure shows the complete circuit of the current switching nanosecond pulse stretcher. When no input is present, the quiescent operating conditions are such that Q_2 and Q_3 are biased into the active region. The quiescent current in Q_2 is adjusted with P_1 so that D_1 conducts approximately 10 microamperes. Since D_1 draws little current, the emitter potential of Q_4 is nearly zero and Q_4 is held in cutoff.

An input pulse enters through the base of emitter follower Q_1. Q_1 drives the differentiating capacitor C_1. A current proportional to the derivative of the input voltage passes through Q_2 to the diode switching circuit, D_1 and Q_4. The signal current switches D_1 off and turns Q_4 on. The output from the collector of Q_4 rapidly charges C_2. As the differentiated pulse returns to zero, Q_4 turns off, leaving a charge on C_1. When Q_4 is turned off, C_2 discharges exponentially through R_1, with a time constant of approximately R_1C_2. R_1 is selected to give the desired decay time of the stretched pulse. The input impedance of emitter followers Q_5 and Q_6 is high compared to R_1 and therefore isolates C_2 from the output load.

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The voltage swing at the emitter of Q_4 is small so that the effect of capacitive feedthrough from emitter to collector of Q_4 during the trailing edge of the input is negligible. There is a slight threshold in the circuit due to the 10-microampere quiescent current in D_1, as well as the charge which is lost in charging the stray capacitance across D_1. This effect is made quite small by choosing C_1 large enough so that the full scale current pulse is large compared to 10 microamperes.

Notes:

1. The rise time of the output pulse in response to a step function is approximately 5 nanoseconds.
2. The differential linearity of the output is 1–2 percent over an output range of 50 millivolts to 10 volts.
3. Additional information is contained in *Rev. Sci. Instr.*, vol. 37, no. 4, p. 514-515, April 1966.
4. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 S. Cass Avenue
   Argonne, Illinois 60439
   Reference: B66-10509

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

Source: R. N. Larsen
Electronics Division
(ARG-82)

November 1966 Brief 66-10510

NASA TECH BRIEF

Low Level Accelerometer Test Methods Are Investigated

The problems associated with testing accelerometers to an accuracy where the standard error is less than 10^{-8} g are centered around the elimination of uncertainties in the acceleration input to the accelerometer. Since absolute gravity can be measured only to approximately 10^{-6} g, the uncertainty in the earth's gravity field is a limiting factor. By placing a test rig in free fall, the uncertainty in the earth's gravity field can be eliminated.

Two basic methods of achieving a free-fall condition are: (1) the use of an airplane flying a parabolic arc, and (2) the use of a satellite. With the airplane a maximum testing time of 30 seconds is available and testing between 10^{-4} and 10^{-6} g input is possible with a precision centrifuge. With the satellite, testing time is essentially unlimited. For both satellite and airplane testing, the limiting factor is the accuracy with which angular velocity of the centrifuge can be measured.

To determine in detail the tests that should be performed on an instrument, the environment in which it will function should be clearly defined. Such a breakdown should include pressure, temperature, and voltage levels, as well as the acceleration level. One possible breakdown is:

(1) Boost guidance
(2) Midcourse navigation
(3) Reentry guidance
(4) Terrestrial or planetary navigation

Each area calls for a different level of accelerometer input. By defining the levels of acceleration that will be experienced, the required test environment can be defined.

In addition to the problem of determining the input field, there exist problems in the accuracy of the test instrumentation. These problems can be broken down into (1) orientation of the accelerometer, (2) measurement of accelerometer output, and (3) measurement of other test inputs such as temperature, pressure, and excitation voltages.

Note:

Further information concerning these test methods is given in "Low Level Accelerometer Test Methods," by H. S. Plourde and Dr. R. H. Nelson, Jr., Report No. E-578, 30 June 1965. Inquiries may also be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10510

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: H. S. Plourde and Dr. R. H. Nelson, Jr.
of Dynamics Research Corporation
under contract to
Marshall Space Flight Center
(M-FS-908)

Category 01

November 1966

Brief 66-10511

NASA TECH BRIEF

Computer Routine Adds Plotting Capabilities to Existing Programs

The problem:

To devise an easy, flexible means of adding a plotting capability to new or existing FORTRAN programs. Programmers often run into problems in trying to adapt programs to provide specific plotting functions while working with a limited memory machine.

The solution:

PLOTAN, a generalized plot analysis routine written for the IBM 7094 computer which minimizes the difficulties in adding plot capabilities to large existing programs. PLOTAN is used in conjunction with a binary tape writing routine, WRITER, which produces an intermediate binary tape. PLOTAN then edits this tape and produces a new tape which may be plotted off-line on the CALCOMP 570 digital incremental plotter.

PLOTAN has the ability to plot any variable on the intermediate binary tape as a function of any other. Flexible input techniques or data and axis labeling minimize user programming changes and their associated costly recompilations. Since only 425_8 storages are required in the user's program, a minimum sacrifice of storage is required.

How it's done:

For the user to generate the intermediate binary tape, he must compile into his program a statement of the following type: CALL WRITER (K, ICASE, A, M, NTAPE, N, MODE) where the variables in the calling sequence are controls for the routine (WRITER) which generates the intermediate binary tape. Each call to WRITER generates one logical record on the intermediate binary tape. This logical record consists of M physical records, where M is input to WRITER which is supplied by the user. The logical record is composed of all the data which the user wishes to put on tape for a particular point.

The user may save the intermediate binary tape and process it at a later time, or, by using the CHAIN feature of FORTRAN II, he may process the tape immediately after it has been generated.

There are three distinct types of input to PLOTAN. The first of these is the intermediate binary tape consisting of N logical records. Additional input is supplied by subroutine KONST which is executed once per job and which defines input parameters or constants that are required by PLOTAN, but seldom, if ever, change. This is accomplished by defining an array, S, of dimension (400) and placing it in common storage. Both BCD (Binary Coded Decimal) and floating point variables are carried in this way. The final input to PLOTAN is provided by subroutine OVERLAY which permits any variable in the S-array to be overlaid at the start of each case. This input is optional and is used to define or redefine any member of the S-array. Thus this subroutine reads all of the input data for PLOTAN that is not "built-in" by subroutine KONST. If all required S's are already defined in KONST, no additional input (other than blank cards) is required.

Using these three inputs, the main routine, PLOTAN, edits the intermediate tape and the desired plotting information is written out on an input tape according to the very rigid format specifications required by the CALCOMP 570 plotter. This tape is then plotted by the CALCOMP off-line plotter.

This routine includes the ability to plot any variable in the binary tape as a function of any other and also has the ability to modify labels and control variables by the use of the OVERLAY technique. In

(continued overleaf)

addition, the program may be used independently to process the intermediate tape or as a second link of a CHAIN job. This eliminates the storage problems normally associated with the incorporation of plotting capability into a large routine.

Notes:

1. A report, entitled "PLOTAN, A Generalized Plot Analysis Routine for the 7094," by Jerry S. Linnekin and JoAnne C. Harris, X-513-65-344, August 1965, and published by Goddard Space Flight Center, Greenbelt, Maryland, contains a listing of the FORTRAN program, an explanation of its construction and use, and a number of sample plots obtained using the routine.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10511

Patent status:

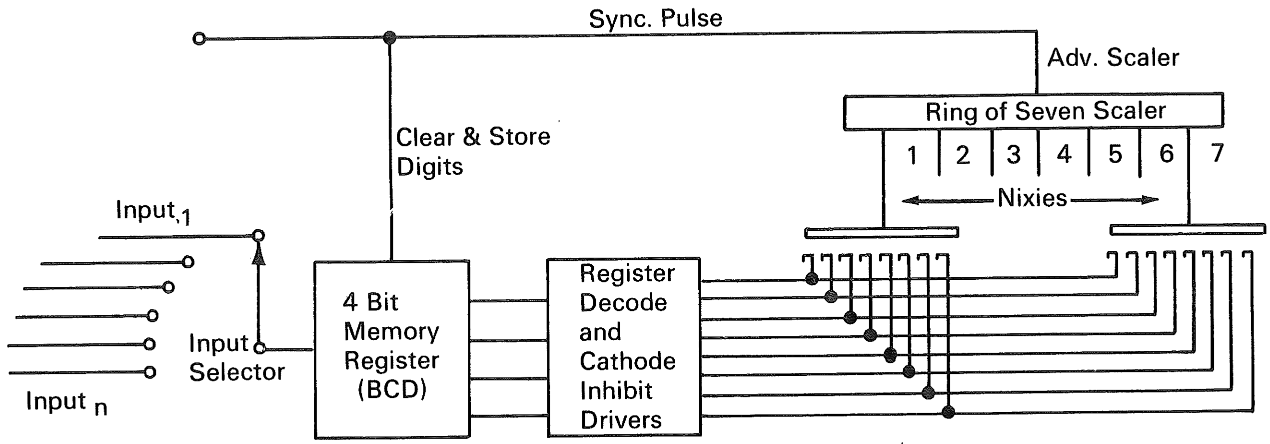
No patent action is contemplated by NASA.

Source: Jerry S. Linnekin and JoAnne C. Harris
of Litton Industries
under contract to
Goddard Space Flight Center
(GSFC-490)

November 1966 Brief 66-10512

AEC-NASA TECH BRIEF

Nixie Tube Display Unit Employs Time-Shared Logic



The problem:

To achieve input switching simplication of a Nixie tube display system. In conventional readout devices, Nixie display tubes are connected so all anodes of all tubes are continuously energized. Events are channeled to the particular Nixie display unit for portrayal. This method requires that each Nixie unit have all of its cathodes individually wired to the event generator, resulting in cluttered circuitry.

The solution:

Wire the cathodes of the display tubes in parallel. Use time-shared logic to energize the appropriate anode and inhibit all unnecessary cathodes.

How it's done:

The system consists of an anode scaler ring, a 4-bit memory register, a master pulse generator, and cathode inhibit circuits. All of the corresponding numeric cathodes of seven display tubes are connected in parallel. The anodes are connected to a seven scaler ring which turns each anode on for 140 microseconds, stepping each anode through the ring and repeating the sequence indefinitely. A scaler output consists of an endlessly repeating train of 28 serial bits (7 digits $\times$ 4 bits per digit). The cathodes are returned to ground through a circuit which can inhibit any unneeded element as determined by the digit stored in a 4-bit memory register. A synchronization pulse from the master pulse generator causes the memory register to store and clear the digits in phase with the advance of the anode scaler. This arrangement makes it possible to display seven decades of data by serially reading the individual digits into the memory register and synchronizing the anode scaler advance to correspond to the digit being read.

Notes:

1. The resulting display repetition rate of approximately 1000 cps completely eliminates visible flicker, while the intensity appears comparable to normal operation. The device provides substantial component savings over full-time parallel systems, while achieving input-switching simplification.

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2. The device has been operating for 2½ years and has required no maintenance.
3. Inquiries concerning this innovation may be directed to:

   Office of Industrial Cooperation
   Argonne National Laboratory
   9700 S. Cass Avenue
   Argonne, Illinois 60439
   Reference: B66-10512

Patent status:

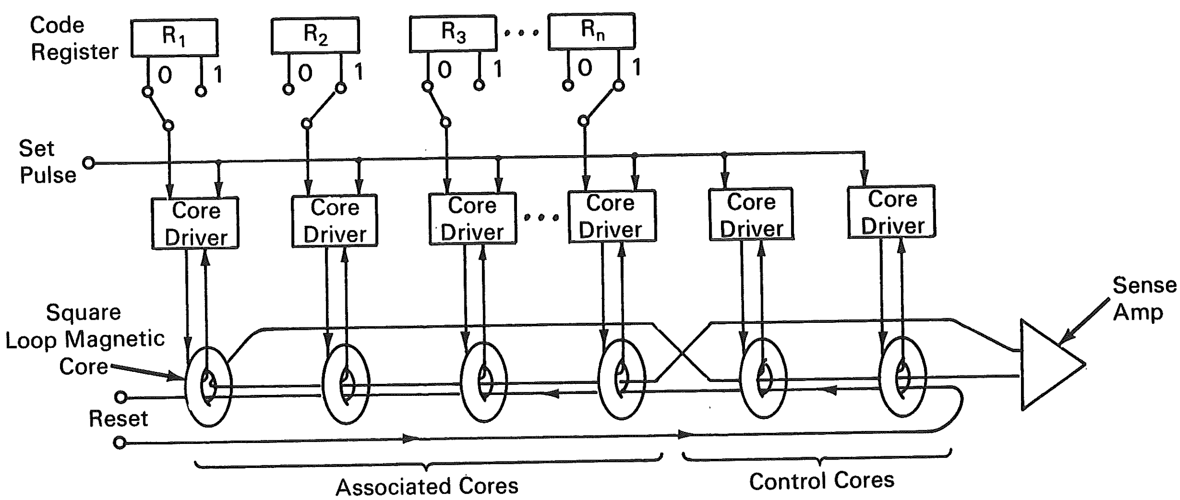
Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

Source: J. Gray
Chemistry Division
(ARG-117)

NASA TECH BRIEF

Digital System Detects Binary Code Patterns Containing Errors



The problem:

In pulse code modulation (PCM) systems, digital code patterns containing errors frequently result in loss of telemetry information. Prior methods of overcoming this deficiency, including conversion to analog voltage pulses and comparison to a reference, have been costly in equipment and time consuming.

The solution:

A system of square loop magnetic cores associated with code input registers to react to input code patterns by reference to a group of control cores in such a manner that errors are canceled and patterns containing errors are accepted for amplification and processing.

How it's done:

All cores are initially in the zero or "reset" state. The code to be compared with the desired code is stored in the register R_1 through R_N. Each register stage has an associated magnetic core and drive circuit. To test for the desired code, each core is "set" if the associated bit is *not* the desired bit. (Thus if the register contains the desired code, no cores would be "set".) In addition the control core or cores are also "set". All cores are now given a "reset" pulse, but only those cores that were "set" will induce a voltage on the sense wire. The sense winding is threaded through the register cores so that the induced voltage will be minus one unit for each core that was "reset". The sense winding is threaded through the control cores so that a voltage of plus one unit of voltage will be induced for each core threaded. The sense amplifier is adjusted to respond to voltages in excess of $+3/4$ unit voltage. If only one control core is used, the sense voltage will exceed $+3/4$ unit only if a perfect code is contained in the register. If one error

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is to be allowed, two control cores are used. In this way, one of the control cores will cancel the induced voltage from the error core and the second control core will cause the sense voltage to exceed +¾ unit voltage. If a perfect code is in the register, both control cores will give +2 units of voltage to the sense amplifier which is more than enough to give an output from the sense amplifier.

Notes:

1. Any number of errors may be tolerated by this embodiment by simply adding additional control cores such that there is one more control core than the number of errors to be tolerated.
2. This technique should improve reception capabilities in PCM telemetry systems.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10516

Patent status:

No patent action is contemplated by NASA.

Source: Ronald M. Muller
and H. Moffette Tharpe, Jr.
(GSFC-541)

November 1966 Brief 66-10518

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Antenna Simulator Permits Preinstallation System Checkout

The problem:

To provide a simple, easily controlled antenna simulator for evaluation checkout of corporate feeds, monopulse sum-and-difference networks, etc. in a shielded environment prior to system checkout on an antenna pattern range.

The solution:

An antenna simulator used for system checkout in place of phase-sensing, amplitude-sensing, and phase-amplitude-sensing antennas.

How it's done:

The simulator consists of four types of components: square hybrids, phase delays, load terminations, and variable phase shifters. Operation is predicated on three weighting circuits with one variable parameter (phase shift) in each. When used in the simulation of a pure phase-sensing antenna, the phase shifts are set so that equal amplitudes emanate. The phases of these signals are then adjusted according to the interferometric equations. In the simulation of a pure amplitude-sensing antenna, the phase shifts are set so that the derived ratios of field strength (voltage) amplitudes are obtained at the output terminals and the signals are made to be cophased (or at most, antiphased) with respect to one another. When used as a phase-amplitude-sensing antenna simulator, an antenna that is neither pure amplitude nor pure phase sensing is contemplated. In this case, the phase shifts provide the desired amplitudes and phase adjustment is provided to simulate the phase relationships among the received signals.

Notes:

1. This technique would be useful wherever simulation of monopulse antenna element characteristics is desired for checkout of ancillary equipment in a controlled environment.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10518

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Richard F. Schmidt
and Armondo D. Elia
(GSFC-522)

Category 01

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Pyrometry Handbook Describes Practical Aspects of Surface Temperature Measurements of Opaque Materials

The problem:

To accurately measure the surface temperature of opaque materials with optical and ratio pyrometers. While there are many techniques available for measuring temperature, usually there is one technique that is best for any given set of circumstances. In practice, the radiation characteristics of the object being measured significantly affect the accuracy of a radiation temperature measurement. The object is often small and subject both to spatial temperature gradients and to energy exchange with neighboring bodies. Techniques must be developed to cope with these problems.

The solution:

A handbook, "Some Practical Aspects of Surface Temperature Measurement by Optical and Ratio Pyrometers," by J. Robert Branstetter, Lewis Research Center, TN-D-3604, September 1966, has been prepared which contains extensive reference literature and results from pertinent experiments to provide a collection of applied technology and reference sources for engineers and technicians. Fundamental equations of radiation are presented along with off-design corrections pertinent to pyrometer measurements. Characteristics of pyrometers, both manual and automatic, and calibration apparatus and techniques are discussed and described. Techniques for minimizing temperature errors resulting from small or awkwardly located sources are analyzed. Precautions and procedures in the selection of emittance, reflectance, and transmittance data are included along with working curves helpful in deriving true temperatures from pyrometer registered temperature readings.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B66-10520

Patent status:

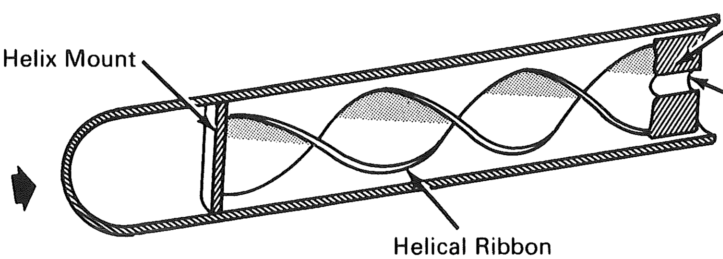
No patent action is contemplated by NASA.

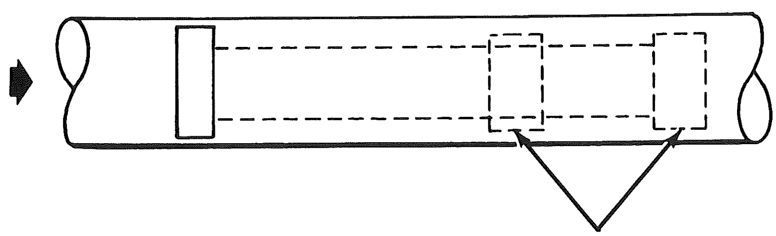
Source: J. R. Branstetter
and D. R. Buchele
(Lewis-349)

Category 01

NASA TECH BRIEF

Flowmeter Measures Flow Rates of High Temperature Fluids





The problem:

To determine the flow rates of various liquid metals at elevated temperatures. Previous flowmeters have suffered because the physical dimensions of flow passage have been dictated by a rather narrow range of expected flow rates.

The solution:

A flowmeter in which flow rate is determined by measuring the position and thus the displacement of an internal float acted upon by the flowing fluid. Viscous forces cause the float to move from its mounted position, affording several means for measuring this motion and thus the flow rate.

How it's done:

The device lends itself to three types of flow rate measurement: electromechanical, pressure drop, and viscous drag. Construction consists of a tube that is rigidly mounted in a passage through which a fluid is flowing. Fastened to the inside of the tube is a helical ribbon formed from an elongated strip that has been twisted about its longitudinal axis to give it spring-like qualities. Rigidly secured to the free end of the helical ribbon is a solid cylindrical float having an outside diameter slightly smaller than the inside diameter of the tube, thus forming an annular space to allow passage of the fluid. Additionally, the

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float may include a center bore to allow passage of the fluid. As the flow rate increases, the viscous force acts to displace the float and this unwinds the helix. In addition to transverse movement of the float, a rotational movement results from the unwinding of the helix. As the float translates and rotates, several means for detecting this motion, and hence the flow rate, are available.

A properly designed solenoid coil covering the region in which the float moves will detect translatory movement of the float by change in its self-inductance.

Pressure taps may be located upstream and downstream from the float, and rate of flow determined by pressure drop as indicated by the output of a differential transducer.

The float may be equipped with a magnetic slug that is specifically oriented with the float in the "no flow" position. Flow rates may then be determined using a gaussmeter that detects the degree of float rotation.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B66-10521

Patent status:

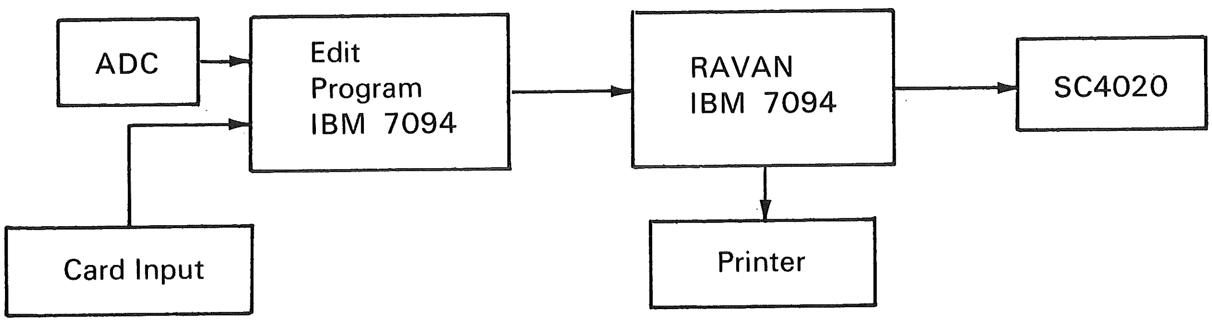
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Alex Vary
(Lewis-328)

November 1966 Brief 66-10525

NASA TECH BRIEF

Computer Program Performs Statistical Analysis for Random Processes



The problem:

To devise a computer program that will perform a variety of statistical analyses on data derived from random processes.

The solution:

Random Vibration Analysis Program (RAVAN), a computer program developed at Marshall Space Flight Center. This program was developed to perform statistical analysis on a number of phenomena associated with flight and captive tests (vibration, boundary layer, acoustics, etc.) but can also be used in analyzing data from many other random processes. Input to the program can come from either punched cards or an analog-to-digital converter, and output can be obtained in either printed or plotted form.

How it's done:

The Random Vibration Analysis Program is written in SHARE Compiler-Assembler-Translator (SCAT) and is designed to operate on the IBM 7094 computer with an IBM 1401 off-line printer and a Stromberg-Carlson 4020 plotter as outputs. If a plotter is not available, the program contains a print-plot option.

RAVAN has many options for various statistical analyses. In addition to basic statistical analysis, the program can calculate the probability density and distribution functions; the Gaussian and Rayleigh functions; the functions of autocorrelation and cross-correlation; the power spectral, cospectral, quadratic spectral, and hanned, or smoothed, cross-power spectral density functions; and the transfer and coherence functions. Tests for stationarity and peak analysis also are available.

Raw data are generally stored on analog tape and digitized by an analog-to-digital converter (ADC), but options are available for punched card input. The output from the ADC is processed by the edit program, which monitors the data for errors and places the converted data into the RAVAN input format. It is mandatory that the input tape to the

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RAVAN be edited and converted to the engineering units of interest. This approach lends itself to installations or organizations that use various ADC output tape formats.

All input and control parameters are initiated by Massey's Automatic Variable Read into Kore subroutine (MAVRIK). This subroutine is a Symbolic Data Loading system for the Supervisory Program Over Other Kinds (SPOOK) system.

Notes:

1. This program is presently being used by several industrial organizations in a variety of applications.
2. A report, entitled "Random Vibration Analysis Program (RAVAN)," NASA TM X-53359, is available and contains a brief description of the mathematical techniques employed and detailed descriptions and flowcharts of the computer program and subroutines.
3. Inquiries concerning this program may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10525

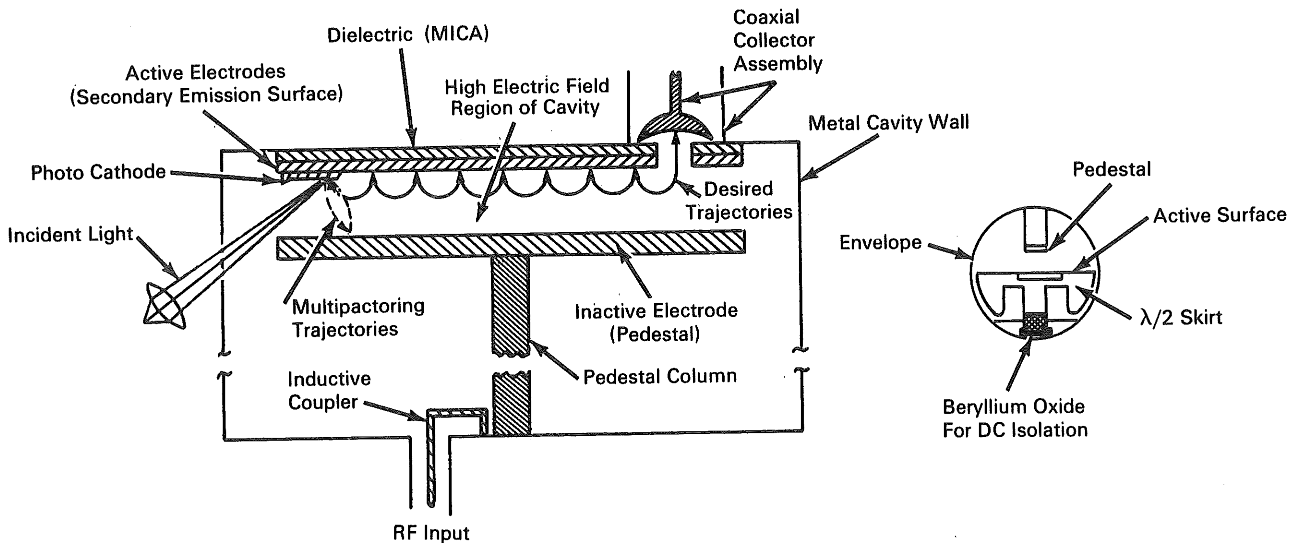
Patent status:

No patent action is contemplated by NASA.

Source: Murl H. Newberry
Marshall Space Flight Center
(M-FS-723)

NASA TECH BRIEF

Improved Design Provides Faster Response Time in Photomultiplier



The problem:

To design a dynamic crossed-field electron multiplying (DCFEM) light demodulator that is smaller and easier to fabricate, assemble, and align; to improve the high vacuum envelope; and to provide electrical characteristics as good as or better than the conventional rectangular configuration DCFEM.

The solution:

A DCFEM that avoids the normal response time limitations inherent in static field devices, by using time varying crossed electric and static magnetic fields to eliminate the transit time spread that affects electrons as they proceed along the secondary emission stages of the tube. The envelope may be fabricated (as shown at the right) in a cylindrical rather than rectangular configuration for improved vacuum and electrical characteristics.

How it's done:

The left figure shows two electrodes assembled in the high electric field region of a rectangular metal cavity that is resonant at three gigacycles. An external magnet supplies a uniform magnetic field. The length of the pedestal column achieves a ¼-wavelength resonance mode.

In operation, incident light on the photocathode produces photoelectrons that are accelerated initially in the positive-x direction during the positive portion of the microwave voltage cycle. The magnetic field shapes the electron paths as shown, and, during the negative portion of the cycle, the electrons are forced to impinge again onto the active electrode where they produce secondary emission electrons. These secondary electrons are accelerated and their path shaped by the magnetic field to force them back onto the active electrode where additional secondaries are produced.

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This process is repeated for n stages, after which the electrons are collected by the coaxial collector assembly.

Notes:

1. The resonant cavity provides the high electric field from a relatively low rf power input.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10526

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Hallicrafters Company
under contract to
Goddard Space Flight Center
(GSFC-451)

November 1966

Brief 66-10529

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Computer Program Searches Characteristic Data of Diodes and Transistors

The problem:

To devise a computer-based filing system which will provide a comprehensive, accurate, and ready reference to characteristic data of diodes and transistors.

The solution:

A semiconductor information storage and retrieval system, which permits selective retrieval of information on diodes and transistors manufactured in the U.S. Any of the following types of information can be searched:

1. Device number
2. Maximum electrical characteristics
3. Typical electrical characteristics
4. Minimum electrical characteristics
5. Manufacturer(s)
6. Specifications to which each device can be procured
7. Numbers of reports describing pertinent reliability, test data, and failure information
8. Applicable comments

How it's done:

The total system is composed of 12 separate digital magnetic tape files. Each file contains the applicable data for a major functional segment of the semiconductor field. Multipurpose devices are listed redundantly. The 12 individual files are:

1. General transistor file
2. Switching transistor file
3. Silicon controlled rectifier file
4. Unijunction transistor file
5. Field effect transistor file
6. General diode file
7. Reference diode file
8. Video detector file
9. RF mixer diode file
10. Switching diode file
11. Tunnel diode file
12. Variable capacitor file

This system makes no attempt to judge the stored data; system design has been focused on providing the facts and suitable reference aids for human selection. When suitable retrieval requests are made of the file, the system will select and present to the user, a listing of part numbered devices that fulfills his requirements. The system can thus be used to supply a complete listing of technical component information necessary for circuit designers, reliability engineers, and quality assurance personnel.

Notes:

1. This program is now in operation at the Goddard Space Flight Center.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10529

(continued overleaf)

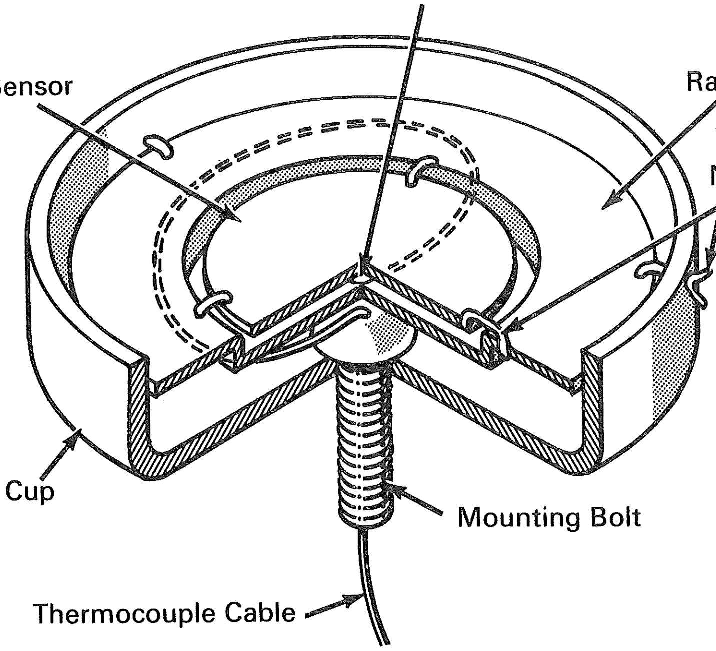
Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act [42 U.S.C. 2457 (f)], to Booz-Allen Applied Research, Inc., 4733 Bethesda Avenue, Bethesda, Maryland.

Source: Booz-Allen Applied Research
under contract to
Goddard Space Flight Center
(GSFC-493)

NASA TECH BRIEF

Heat Flux Sensor Design Reduces Extraneous Source Effects



The problem:

To design a heat flux sensor (temperature transducer) that features good thermal isolation from undesirable heat sources, and is reliable and relatively inexpensive to produce.

The solution:

A heat flux sensor that isolates the sensor and its transmitting thermocouple from undesirable heat sources by incorporating a radiator section that forms a radiation shield between mounting cup and sensor.

How it's done:

The sensor, radiator, and cup are all of gold-plated aluminum. The radiator is held in place in the mounting cup by nylon cord tied in three places equidistant about the periphery of each. In like fashion, the sensor is held in place within the circular depression in the center of the radiator. The thermocouple is bonded to the underside of the sensor at its center and the thermocouple cable is routed around and bonded to the underside of the radiator, then led out through the drilled passage in the mounting bolt.

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The mounting cup is highly polished on its outer surface to reflect radiant heat.

Notes:

1. Bonding of the thermocouple cable to the underside of the radiator provides a conductive path to dissipate extraneous heat that might otherwise reach the sensor.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10531

Patent status:

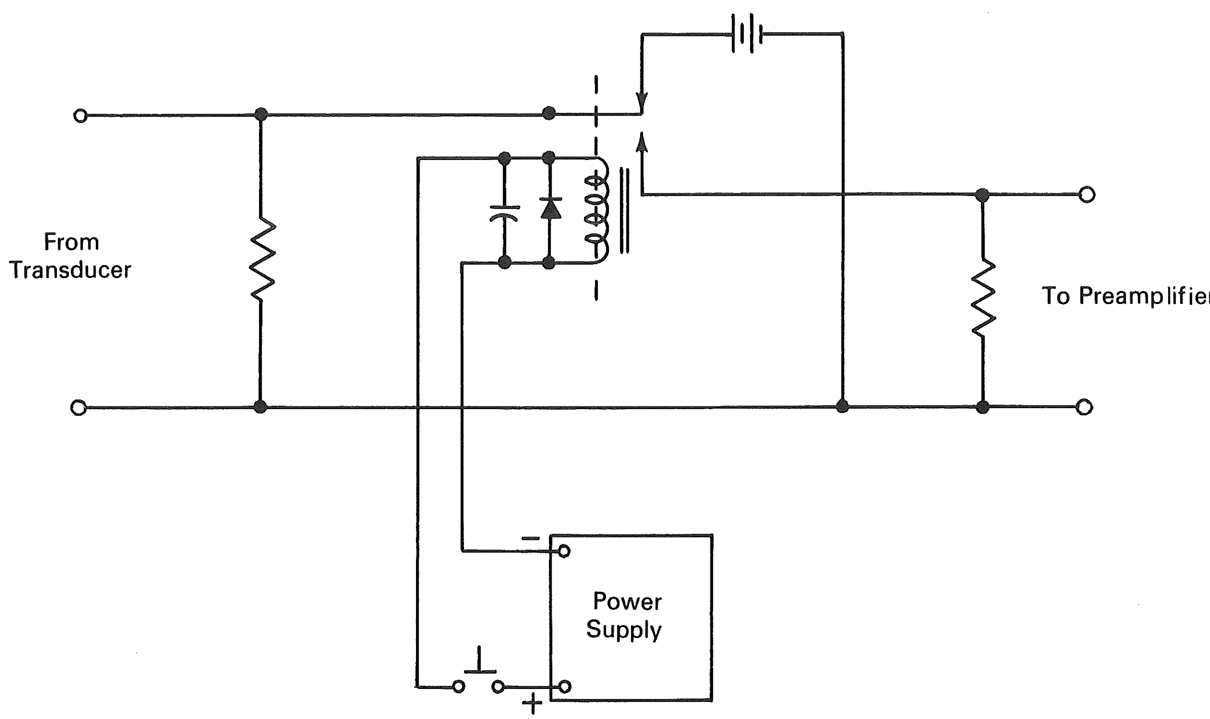
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: G. P. Robinson and E. D. Crofts
of McDonnell Aircraft Corp.
under contract to
Manned Spacecraft Center
(MSC-400)

November 1966 Brief 66-10533

NASA TECH BRIEF

Method Permits Mechanical and Electrical Checkout of Piezoelectric Transducers While Installed in a System



The problem:

To devise a simple and reliable method to permit checkout of the mechanical and electrical condition of piezoelectric transducers of the cantilever beam type, while installed in a system. In this type of transducer, the sensing element serves also as the spring. Prior methods involved the simulation of the transducer output by inserting a voltage into the system which could be used to evaluate the condition of the electronics, but did not permit an evaluation of the mechanical condition.

The solution:

Apply a known dc voltage to the piezoelectric element and then remove the voltage suddenly. This causes the beam to vibrate at its natural frequency and decay in accordance with whatever damping is present. The sensitivity is related to the maximum

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deflection of the element, and the mechanical condition of the element is indicated by the natural frequency and character of the waveform.

How it's done:

A known dc voltage is applied to charge the piezoelectric element which will deflect by an amount directly proportional to the applied voltage. The charge is then removed by energizing a relay. This energy is dissipated through a resistor, and the potential energy induced by deflecting the element is dissipated by the damping of the spring mass system. These two dissipations of energy occur concurrently, with the surge charge dissipating first. The element then continues to vibrate at its natural frequency at a decay rate depending upon the amount of damping. The sensitivity is related to the maximum deflection, and the mechanical condition is indicated by the natural frequency and character of the waveform. Any change from the original condition such as a change in end fixity, cracks in the element, or mass loss can be readily detected. A diagram of the test circuit is shown.

Notes:

1. A cantilever beam type piezoelectric transducer is described in Tech Brief B66-10534, "Miniature Piezoelectric Triaxial Accelerometer Measures Cranial Accelerations," November 1966.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10533

Patent status:

No patent action is contemplated by NASA.

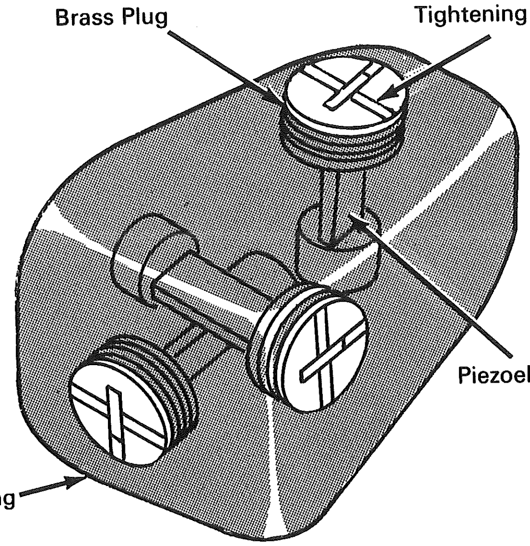
Source: V. L. Rogallo and R. S. Jenkins
(ARC-73)

November 1966

Brief 66-10534

NASA TECH BRIEF

Miniature Piezoelectric Triaxial Accelerometer Measures Cranial Accelerations



The problem:

To design and build a triaxial accelerometer to measure human cranial accelerations when a subject is exposed to a centrifuge or other simulators of g environments. The size and shape must be suitable for attachment to the teeth without discomfort.

The solution:

A tiny triaxial accelerometer whose sensing elements are piezoelectric ceramic beams. The accelerometer physical shape is compatible to a human mouth and may be attached to the teeth by an appropriate bridge and located behind the upper teeth in the roof of the mouth. The sensitivity is about 20 millivolts (rms) per g and the frequency response is essentially flat over the range tested (5 to 500 cps).

How it's done:

The accelerometer consists of three orthogonal cantilever beams of piezoelectric ceramic material mounted in an aluminum case having external dimensions approximating those of a human molar. The beams are 0.2-inch in length and each has a gold weight bonded to the free end. The beams are located in a slot cut in a brass threaded plug and bonded in place with a nonconductive epoxy cement.

All three elements are made identical as far as possible. A slot on the brass plug face provides an alignment reference. Insulated soft copper wires are soldered to the top and bottom electrodes of each beam and passed through the open slot of the plug along the beam side. The elements are then inserted

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into the housing and potted in place with epoxy cement.

Notes:

1. In testing, the linearity for all components proved to be excellent. Sensitivity was of the order of 20 millivolts (rms)/g. The repeatability was excellent and the response was essentially flat over the entire range tested (5 to 500 cps). The cross axis sensitivity did not exceed 5.5 percent.
2. A related innovation is described in NASA Tech Brief B64-10004, "Ultrasensitive Transducer Advances Micromeasurement Range," May 1964. A method of testing piezoelectric transducers is described in NASA Tech Brief B66-10533, "Method Permits Mechanical and Electrical Checkout of Piezoelectric Transducers While Installed in a System," November 1966.
3. This device could be considered for application in dental, medical, and automotive safety research.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B66-10534

Patent status:

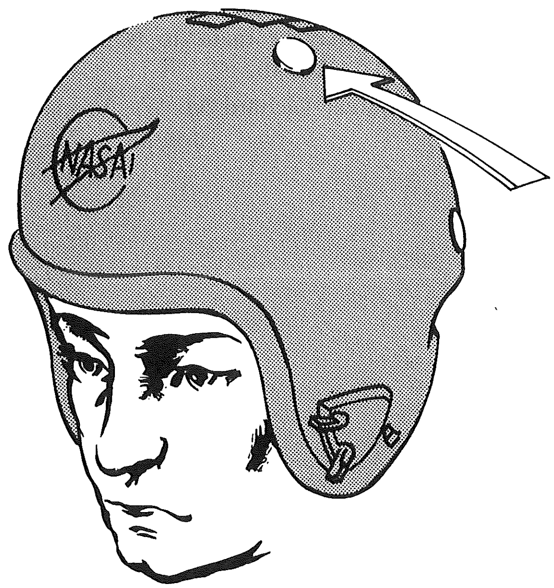
No patent action is contemplated by NASA.

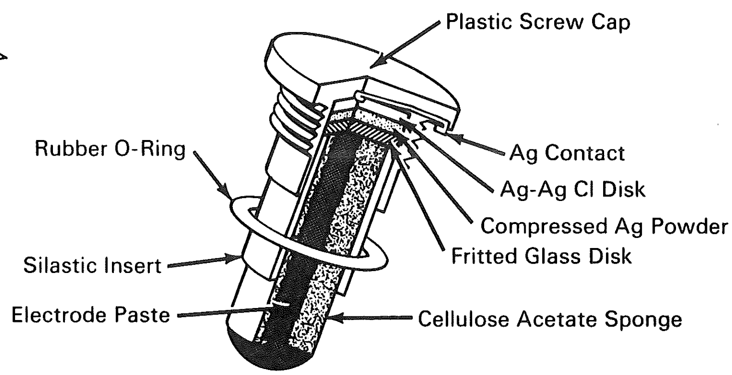
Source: V. L. Rogallo and G. J. Deboo
(ARC-71)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Helmet System Broadcasts Electroencephalograms of Wearer





The problem:

To develop an improved system for obtaining electroencephalograms (EEG's) of pilots and astronauts performing tasks under stress. In the past, electrodes were cemented to the scalp and were uncomfortable, irritated the scalp, and took as long as an hour to attach. Furthermore, the wires to the readout equipment restricted the subject's motions.

The solution:

An EEG monitoring system consisting of non-irritating sponge-type electrodes, amplifiers, and a battery-powered wireless transmitter, all mounted in the subject's helmet. No preparation of the scalp is required. After a quick initial fitting, the helmet can be removed and replaced without further adjustment. There are no external wires.

How it's done:

A flight helmet is modified to contain the EEG electrodes and the electronic components. The elements of the system fit conveniently in the helmet and do not impair its usefulness as a protective device.

The key element in this system is the EEG electrode, which consists of a flexible portion that rests against the scalp and a rigid portion that fits securely in the helmet and is connected to the amplifier. The flexible portion consists of a hollow-core cellulose acetate sponge impregnated with an electrode paste. The rigid portion consists of the following: a disk of fritted glass wetted with a saline solution; a disk of compressed silver powder; a disk of Ag–AgCl; and a solid silver contact which connects with the amplifier.

Fitted to the subject, the sponge portion containing the electrode paste contacts the scalp with a light

(continued overleaf)

steady pressure. This member can accommodate a certain amount of relative motion between the scalp and the helmet without altering the electrical properties of the connection or distorting the signal.

The remaining elements of the system are a pair of miniature biomedical amplifiers, a pair of commercially available FM subcarrier oscillators, a miniature PM transmitter operating at 108 MHz, and standard miniature mercury cells that provide 90 hours of continuous operation.

Notes:

1. The helmet shell comes in three basic sizes, and by selection of liner size and length of replaceable sponge, the helmet can be adapted to any subject. Initial fitting requires only about five minutes.
2. Experiments with a variety of subjects (some with thick hair, with and without hairoil, and some bald) have been made in the laboratory, in flights of a T-33 airplane, and in centrifuge runs. The data obtained have been consistent with EEG records obtained with carefully applied metallic electrodes.
3. A related innovation is described in NASA Tech Brief B65-10203, July 1965.
4. Inquiries may also be directed to:

    Technology Utilization Officer
    Ames Research Center
    Moffett Field, California 94035
    Reference: B66-10536

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Richard M. Westbrook and
Joseph J. Zuccaro
(ARC-70)

November 1966 Brief 66-10539

NASA TECH BRIEF

Computer Programs Perform Spectral Analyses of up to Seven Time Series

The problem:

To devise computer programs that will describe the interrelationships between two or more time series in situations where simultaneous measurements of the time-varying quantities are recorded in an experiment.

The solution:

Two computer programs that will perform statistical spectral analysis of up to seven time series. One of these programs is specifically for cross-spectral analysis of two stationary time series, and the other for performing a multidimensional spectral analysis of up to seven time series from stationary or nonstationary processes. These programs are available in both Fortran II and Fortran IV versions.

How it's done:

The cross-spectral analysis program takes as input two stationary time series from simultaneously measured sample records. Multiple cases are treated sequentially, and the time series as well as all the other input data may differ in any respect from one analysis to another. For data input purposes, the X (input time series of the linear model) and Y (observed output) time series sample records are handled in an independent manner. Initially, the two sample records need not consist of the same number of points, nor to have been sampled at the same rate. When this is the case, the program will reduce the effective sampling rate of the data prior to the cross-spectral analysis as indicated by one of the control variables. After any desired sampling rate reduction has been accomplished, for either time series, the resulting sample records are calibrated by the application of multiplicative calibration factors and trends are derived from the resultant sample records. The program then computes estimates of the autocovariance and the cross-covariance functions and then obtains smoothed estimates of the power spectral densities, cospectral density, and quadrature spectral density. From these, estimates of the coherence and frequency response functions are derived.

In addition to trend removal and arbitrary prescaling of the time series, the program provides other auxiliary features such as tests of significance of convex power peaks, corrections for frequency response characteristics of the measurement system, and corrections for filters employed in the generation of the time series input. A variety of modes of data input and output are available on a user option basis, including CRT plots of the various functions estimated.

The multidimensional spectral analysis program performs the same types of calculations as those described above when dealing with stationary time series, but, in addition to computing the coherence and frequency response pertaining to each pair of time series, it also computes multiple coherence functions relating any one of the time series to the remaining ones. In addition, if two or more of the time series are chosen as inputs and the remaining series as outputs in a linear time-invariant system model, the program provides estimates of the matrix frequency response function of the system and computes related quantities.

For nonstationary time series, this program computes time-varying estimates of the types described

(continued overleaf)

by automatically partitioning the total sample record into equal-length overlapping subrecords. A complete multiple spectral analysis is then carried out for each subrecord and each time-varying estimate obtained may then be analyzed to obtain estimates of quantities such as spectra of power fluctuations or spectra of coherence.

A high degree of flexibility is also available in this program because of the modular design and the many user-controlled input and output options.

Notes:

1. These programs should have applicability to a variety of engineering systems in the fields of geophysics, physiology, acoustics, and structural analysis. One possible application would be in testing the dynamic response of structures under wind loading.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10539

Patent status:

No patent action is contemplated by NASA.

Source: M. R. Dubman and B. J. Byars
of North American Aviation, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-1133 & 1134)

November 1966

Brief 66-10541

NASA TECH BRIEF

Computer Used to Program Numerically Controlled Milling Machine

In order to use a numerically controlled milling machine to its ultimate capacity, a computer program has been devised that automatically directs the machine, on command, through a series of cutting and trimming actions whose extent is unlimited from zero through 360 degrees of swing.

Called the Flight Simulate Cam Program, it accepts engineering data points, passes smooth curve segments through the points, breaks the resulting curves into a series of closely spaced points, and transforms these points into the form required by the cam mechanism. It then calls the APT numerical control programming system to produce a control tape that is used to produce the desired cam profile with a numerically controlled milling machine.

The series of closely spaced points obtained from the curve fitting routine is checked to determine if the input data has caused an unusable "smooth" curve to be created, as a curve that reverses the time axis, a curve that extends beyond the zero to 100% cut boundaries, or a curve containing slopes too steep for the follower to track. If any of these conditions exist, an error comment is printed and that case is deleted. A printer plot is generated that shows the function curve produced by the cam program. The plot also contains tabular data for each degree of cam rotation in terms of cam angle versus percent cut and the corresponding values in the same scale as the original input data. The curve points are transformed by mapping them into the quasi-circular configuration required by the cam mechanism. Allowance is made in this transformation for the angular progression and regression, relative to the camshaft axis, of the follower center as it moves within the zero to 100% cut radial limits. The radial distance of the follower from the cam center is computed at each point to produce the proper angular rotation of the cam follower arm. These transformed points are used as the profile cutting data points in an APT part program generated by the cam program.

When all cases have been processed, the cam program turns processing control over to the APT system, which uses the APT part programs generated by the cam program, to generate a machine control tape for each case. These tapes can be used on a numerically controlled milling machine to produce the desired cams.

Notes:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10541

Patent status:

No patent action is contemplated by NASA.

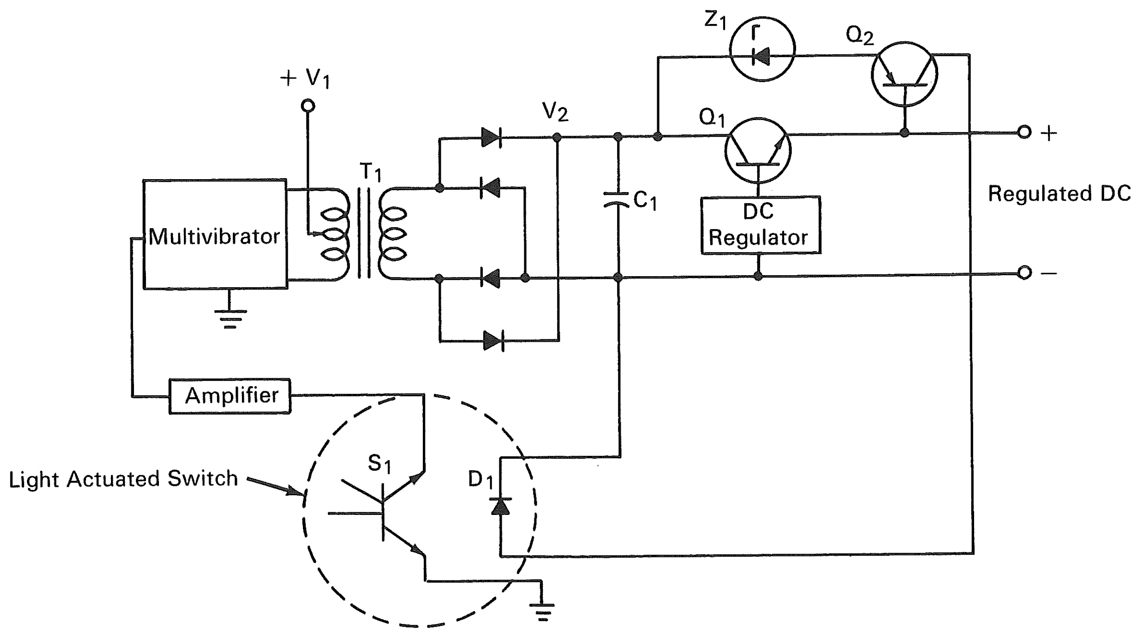
Source: T. C. Harris
of General Electric Company
under contract to
Marshall Space Flight Center
(M-FS-1608)

Category 01

November 1966 Brief 66-10542

NASA TECH BRIEF

Preregulator Feedback Circuit Utilizes Light Actuated Switch



The problem:

To provide a simple and efficient feedback device in a power supply preregulator which maintains dc isolation between input and output grounds. Because the series regulator transistor in a conventional series regulated supply has a tendency to overheat during a high input voltage condition, it is desirable to provide a means of protection. A zener shunt regulator has been utilized to reduce the transistor load, but is very inefficient. While preregulation can be made efficient, conventional feedback techniques will not provide the required dc isolation.

The solution:

A preregulator feedback circuit employing a Light Actuated Switch (LAS). The LAS consists of a diode PN junction infrared source close to, but electrically isolated from, a photodetector with characteristics of a symmetrical bilateral switch. Its function is to maintain dc isolation between the input and output while transferring a signal used to control applied power.

How it's done:

The circuit shows the application of a LAS as a feedback device. During high voltage operation of the power supply, overvoltage sensor Q_2, sensing the voltage across series regulator Q_1, provides a control signal to the LAS. As the current increases through the input diode D_1 of the LAS, switch S_1 will turn on and control the biasing of the multivibrator to inhibit its operation. Thus, with no voltage induced

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in the secondary of T_1, the charge on C_1 will decrease, lowering the voltage across Q_1 to the normal regulation level. As this level is attained, the LAS switches off permitting the multivibrator to resume operation. The circuit will continue to cycle through off periods to prevent excessive series regulator voltage as long as a high input voltage condition exists.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10542

Patent status:

No patent action is contemplated by NASA.

Source: T. P. Hayser
of International Business Machines Corp.,
under contract to
Marshall Space Flight Center
(M-FS-1180)

November 1966 Brief 66-10543

AEC-NASA TECH BRIEF

High-Reluctance Rotor Rings Improve Homopolar Generator Performance

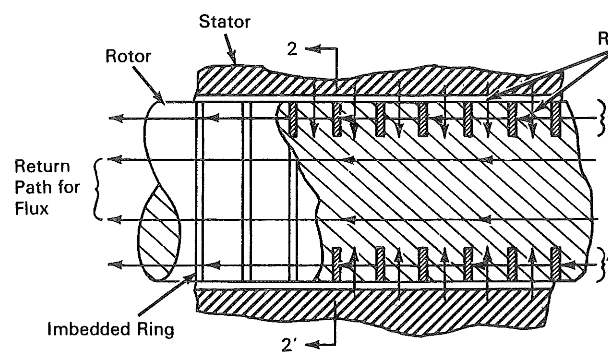

FIGURE 1

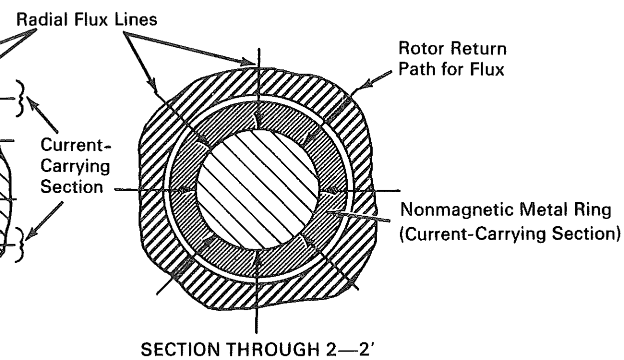

FIGURE 2

The problem:

To devise a means of keeping the induction flux entering the rotor of a homopolar generator in a radial path. In the present state of homopolar generator construction, the induction flux has a pronounced tendency to deviate from its radial path shortly after entering the rotor. The maximum induced EMF is obtained when the induction flux enters the rotor radially. Also, machine efficiency can be controlled by varying the radial depth of the flux path.

The solution:

Nonmagnetic metal rings are imbedded in the generator rotor normal to its axis, forcing the flux to remain radial as it penetrates the periphery of the rotor.

How it's done:

A homopolar generator consists of a cylindrical rotor of solid iron or steel and a stator enclosing the rotor. The stator contains a field winding which produces a radial magnetic field. A series of nonmagnetic metal rings made of copper or aluminum are imbedded in the rotor, normal to its axis, as shown in figure 1. The rings present a high reluctance magnetic path near the periphery of the rotor, but present no additional impedance to the longitudinal electric current. The high reluctance path forces the flux to penetrate the rotor in a radial path throughout the entire depth of the current-carrying cross section. The electric current-carrying cross section is clearly defined by the inner and outer diameter of the rings, separating the current-carrying portion of the rotor from the magnetic return path (figure 2). The outer diameter of the rings is approximately equal to the diameter of the rotor, while the inner diameter is a value defining an optimum current-carrying cross section for the particular requirements of the machine.

Use of the rings permits optimum rotor design for any given set of operating requirements and simplifies the task of predicting the operational characteristics

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of the generator. Excitation power requirements are considerably decreased and voltage regulation is improved.

Note:

Additional information concerning this innovation is given in U.S. Patent No. 3,217,199 available from U.S. Patent Office. Inquiries may also be directed to:

Office of Industrial Cooperation
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439
Reference: B66-10543

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

Source: E. E. Musset
Physics Division
(ARG-104)

NASA TECH BRIEF

Ultrasonic Quality Inspection of Bonded Honeycomb Assemblies Is Automated

The problem:

To design an inspection system for bonded honeycomb assemblies that is accurate, fast, and automated. The size and complexity of the panel sections to be inspected ranged from 12 to 33 feet in diameter, and consisted of cylindrical, truncated, hemispherical, and flat sections of varying lengths and nonsymmetric internal and external protrusions. The inspection record would have to indicate clear, interpretable, and precisely situated test results capable of displaying the unbond conditions as to the size and extent of the unbond.

The solution:

An ultrasonic inspection system that consisted of inner and outer transducer positioning assemblies with suitable motor controls, a centerless turntable assembly to rotate the test parts, water squirter assemblies to assure the watertightness of joined areas, and an inspection program that was completely encoded on tape suitable for use on a high speed computer.

How it's done:

Each assembly required careful preparation prior to its inspection to assure that water from the squirter assemblies could not enter through joined areas. The prepared assembly was then located in place on the turntable with the applicable tooling. The position and relative clearance of the assembly surface, and the instrumentation, recording model, and all program controls were readied for an automatic inspection as required by the specific test. All suspect recorded void areas were further evaluated by complementary ultrasonic techniques such as contact, resonant, frequency shift, sonic, and dimensional checks to locate voids to their respective sides and interfaces to facilitate their repair.

Eight-channel tape readers were utilized as the program control. Since the position and gimbal motions of both the inside and outside transducer assemblies required an independent program, six channels were designated for their control. One channel was used to control the transducer positioning logic during an automatic inspection cycle and the eighth remaining channel was used to control the turntable angular velocity necessary to maintain a uniform surface inspection speed and recorder writing density.

The program information was generated with the aid of a high speed computer coded with the necessary mold line equations for both the inner and outer surfaces of the specific panel assembly. A complete series of calculations was performed and the data was stored on magnetic tape and transferred, by a punched tape computer, to mylar tape in a usable coded form.

The programmed tape is indexed past the tape reader photocell head to initiate the operation of each controlled function. Since the tape reader is only required to initiate automatic programmed transducer indexing each turntable revolution, the function is provided with a control to permit the transducer index increment to be adjusted by the operator.

Notes:

1. More than 500 Apollo and Saturn S-II adhesive bonded assemblies have been successfully inspected since the installation of the ultrasonic inspection systems.
2. The adaptation of punched tape-reader programming to ultrasonic inspection systems contributed to the feasibility of systems capable of automatically inspecting geometric shapes previously considered impractical.

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3. This programmed method of positioning should readily adapt itself to many other complex positioning and synchronizing needs frequently encountered by inspection departments.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10544

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

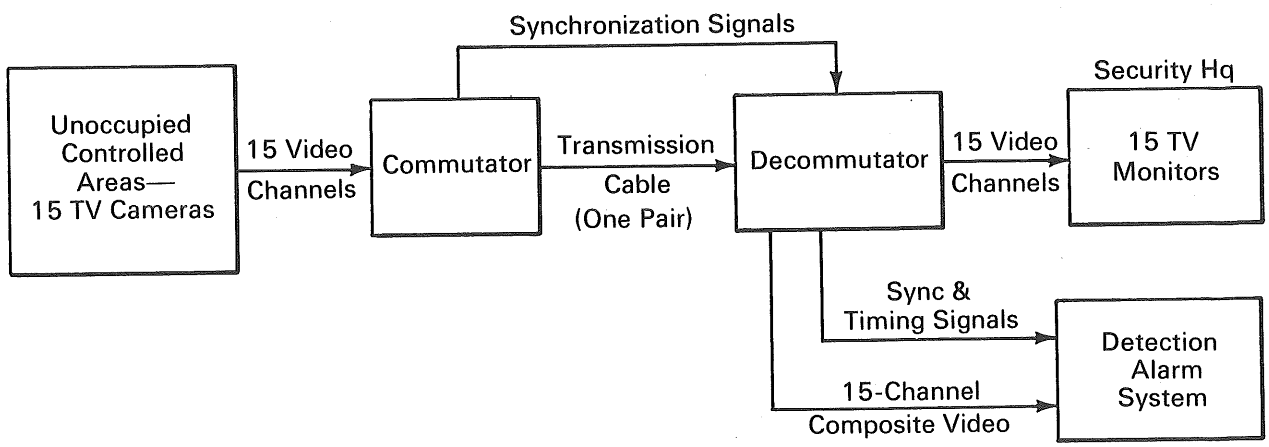
Source: C. C. Kammerer
of North American Aviation, Inc.,
under contract to
Manned Spacecraft Center
(MSC-859)

November 1966

Brief 66-10548

NASA TECH BRIEF

Security Warning System Monitors up to Fifteen Remote Areas Simultaneously



15-CHANNEL MOTION DETECTION SYSTEM

The problem:

To develop a security warning system that is capable of monitoring several remote or unoccupied areas simultaneously. In addition, the system must also permit visual surveillance of each area. At present, no such system is commercially available. One company has designed a prototype, but it works with only one television camera and monitor.

The solution:

A video motion detection system, consisting of 15 television cameras, monitors, and associated circuitry, that utilizes a commutator and decommutator, allowing time-multiplexed video transmission. When motion is detected by a camera the system alarm sounds at security headquarters and an appropriate warning indicator lights.

How it's done:

The television cameras are located in remote or unoccupied areas. Video signal frames from 15 television cameras are sequentially combined within the commutator and transmitted along one cable pair to the decommutator. The decommutator reconverts the composite signal to the original video signal frames and channels them in proper sequence to 15 television monitors. The composite signal to the decommutator is also fed from the decommutator receiver to the detection alarm rack. The detection alarm system and the television monitors are housed in an equipment rack at security headquarters.

The detection alarm system inverts the first 15 frames (1 from each camera) of the composite signal and records them on a video magnetic tape loop. The

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inverted frames are then played back and compared with the subsequent 15-frame groups received. If there is no motion in the monitored areas, these synchronized positive and negative signals will cancel each other. However, if there is motion, the corresponding frames of the video signals will not match, and the system will generate an output to the proper warning indicator and the system alarm.

The initial record phase requires only 1/2 second. One complete scan of 15 frames of channels (1/30 second per frame) is fed through an isolation amplifier to an inverting amplifier and recorded on a video magnetic tape loop. A flip-flop circuit, controlled by a gate signal from a tape control switch, allows only 1 complete scan of the 15 channels to be inverted and recorded. The second gate signal of the decommutator resets the flip-flop, which, in turn, disables the recording circuit.

During the operating phase of the detection alarm system, a video tape recorder plays back the inverted 15 frames of video through an adjustable delay line (to insure proper synchronization) to an adder circuit. The adder circuit receives both a positive-going waveform (the composite video signal from the isolation amplifier) and a negative-going waveform (the recorded video signal from the tape loop). The signals are algebraically added in the adder circuit and an output voltage is produced only if there is a difference. A difference will occur if any motion is detected. Regardless of the adder output polarity, one of two Schmitt-trigger circuits will be triggered at a preset detecting level. The Schmitt-trigger pulses are gated and a simultaneous trigger pulse from the Schmitt trigger circuit produces an output from a one-shot multivibrator circuit. The output of the one-shot multivibrator is amplified, energizing a monitor indicator light, the equipment-rack indicator light and the system alarm.

If any motion is detected by a television camera, one of the Schmitt trigger circuits will produce an output simultaneously with a gate signal and the appropriate monitor indicator lamp will light. A reset button, located on the equipment rack, will restore any trigger circuit to an operational state when desired.

Notes:

1. This security system could be used in industrial and retail establishments; banks, large retail stores, warehouses, and factories are a few examples.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Kennedy Space Center
   Kennedy Space Center, Florida 32899
   Reference: B66-10548

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

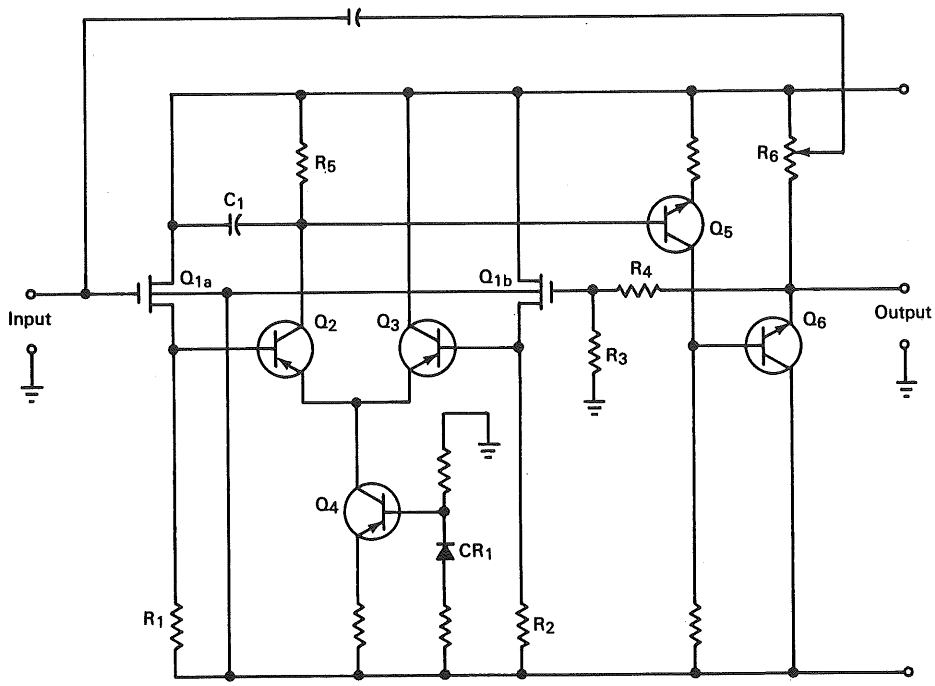
Source: R. C. Fusco
of Radio Corporation of America
under contract to
Kennedy Space Center
(KSC-66-39)

November 1966

Brief 66-10549

NASA TECH BRIEF

Miniature Electrometer Preamplifier Effectively Compensates for Input Capacitance



The problem:

To design an electrometer preamplifier that can be used with intracellular microelectrodes in recording bioelectric potentials. The requirements of such a device are low input current, high input impedance, low noise, low output impedance, and small size.

The solution:

A negative capacitance preamplifier using a dual MOS (Metal Oxide Silicon) transistor in conjunction with bipolar transistors.

How it's done:

The input signal is coupled to the gate of Q_{1a}, which is one half of a dual MOS transistor used in a differential amplifier configuration. Temperature compensation is achieved automatically by differential action and because both halves of the MOS transistor, Q_{1a} and Q_{1b}, are diffused on a single substrate. The required open loop gain is provided by Q_2, Q_3, and Q_5, and a low output impedance by Q_6. The temperature drift of Q_4, a constant current generator, is

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compensated by CR_1. Resistors R_1 and R_2 are important for two reasons. First, they cannot be omitted because the source currents then will be limited to the base currents of Q_2 and Q_3. Such low currents will result in a voltage gain of considerably less than unity for Q_{1a} and Q_{1b} because of the low transconductance achieved with MOS devices at low current levels. Second, they can be adjusted to regulate the drain current so that the temperature coefficient of the gate-to-source voltage is approximately zero. Resistors R_3 and R_4 form a 2:1 negative-feedback potential divider, which sets the closed loop gain at 2. Resistor R_5 is shunted by C_1 to assure stability. If the negative capacitance control potentiometer, R_6, is overadjusted, the circuit will oscillate, but if the circuit is adjusted for critical damping, then it is stable.

A common technique often used to reduce the effects of input capacitance is bootstrapping; unfortunately, this technique cannot compensate for source capacitance when it is not accessible. Using the amplifier in a particular application, it was determined that an inaccessible input capacitance of approximately 5 picofarads existed. After adjustment of the negative capacitance control, an effective input capacitance of 0.4 picofarad was measured. This is an effective reduction of input capacitance by more than an order of magnitude.

Notes:

1. Although MOS field effect transistors exhibit 10–20 db greater noise levels than junction field effect transistors, other considerations, such as the acceptance of extremely low current, noncritical adjustment, ease of temperature compensation, and small size favor the use of the MOS transistor.
2. Although the preamplifier was designed for use with intracellular microelectrodes, it should be applicable to a wide variety of measurements, especially where stable wideband dc amplification from high impedance sources is required. Such applications would include their use as a pickup plate video amplifier in storage tube tests and for pH and ionization chamber measurements.
3. Inquiries concerning this invention may be directed to:

    Technology Utilization Officer
    Ames Research Center
    Moffett Field, California 94035
    Reference: B66-10549

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Gordon J. DeBoo
and Clifford N. Burrous
(ARC-69)

November 1966 Brief 66-10552

NASA TECH BRIEF

Nonelectrolytic Tantalum Capacitors Developed

The development of a large area, nonelectrolytic tantalum foil capacitor has recently been accomplished. The capacitor consists of a number of tantalum foils with 3- by 1- by 0.005-inch dimensions, connected in parallel and wound into a cylinder 0.25 inch in diameter by 1 inch long. This capacitor has a capacitance of approximately 1 microfarad and is capable of operating at 125°C at 150 volts with an insulation resistance of at least 1 megohm. The devices constructed demonstrate that fairly stable nonpolar, nonelectrolytic tantalum capacitors can be built from foil to operate at elevated temperatures and voltages.

As in electrolytic capacitors, the dielectric of this capacitor consists of an anodized tantalum oxide film, but with one exception: instead of the tantalum metal and an electrolyte acting as electrodes, aluminum films evaporated directly on the two oxide surfaces act as the electrodes. The tantalum foil is merely the carrier for the two oxide films and connects the two in series. This capacitor, unlike the electrolytic variety is symmetrical and, therefore, nonpolar.

Notes:

1. In tests at a potential of 100 volts, capacitors of this design have remained stable through a temperature range from 25° to 125°C for periods up to 100 hours.
2. Inquiries concerning this investigation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10552

Patent status:

No patent action is contemplated by NASA.

Source: Cornell-Dubilier Electric Corporation
under contract to
Marshall Space Flight Center
(M-FS-1546)

Category 01

November 1966 Brief 66-10553

NASA TECH BRIEF

Computer Programs Calculate Potential and Charge Distributions in a Plasma

The problem:

To devise a set of computer programs for determining the potential and charge distributions between two electrodes in a plasma in a variety of geometries.

The solution:

Computer programs are written to determine solutions of the Vlasov equations for plane, cylindrical, and spherical geometries. Potential and charge density distributions are found for each of these configurations over a range of conditions. Values of the independent parameters of bias potential, electrode spacing (in Debye lengths), and charge density ratio are chosen so as to provide a variety of solutions.

How it's done:

The report, entitled "Computer Solutions of the Vlasov Equations," studies solutions of the collisionless Boltzmann or Vlasov equations for two related physical problems.

In one problem, designated the diode problem, the objective is to predict current-voltage characteristics between two electrodes, an emitter and a collector, in the presence of a plasma. Primary attention is given to an emitter on which charged particles are formed. In principle, the electron current of positively and negatively charged particles leaving the emitter may be varied quite independently, and the motion of the charged particles after leaving the emitter is determined by the electrostatic field distribution. The diode configurations in this problem either have an electrode spacing which is small compared to the radius of curvature, or are concentric cylindrical or spherical situations with the collector external to the emitter.

In a second problem designated the probe problem the intent is to predict the disturbance caused by a small object at some enforced bias potential relative to a much larger (or nearly infinite) container. The disturbance involves, in general, both a local departure from an essentially neutral plasma and a charged particle current of one sign or the other from the plasma to the probe. Cylindrical or spherical symmetry is implied by the definition of the problem. The distinguishing feature of the probe problem compared with the diode problem is that most of the particles of either sign leave the emitter with a velocity component perpendicular to the radius, which prevents them from negotiating the bias potential barrier to the collector or probe. Instead, these particles follow trajectories that become entirely tangential at some radius, and finally return to the emitter.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10553

Patent status:

No patent action is contemplated by NASA.

Source: David C. Prince and N. P. Jefferies
of General Electric Company
under contract to
Marshall Space Flight Center
(M-FS-871)

Category 01

November 1966 Brief 66-10555

NASA TECH BRIEF

A Fast-Neutron Spectrometer of Advanced Design

The problem:

To design and develop a fast-neutron spectrometer for spectral measurements requiring a combination of good resolution, high efficiency, and rapid response. Accurate measurements are required of fast-neutron fluxes of 10^8/cm^2/sec to 10^{10}/cm^2/sec, within a gamma field as high as 1.5×10^6R/hour and a time limit of 5 seconds.

The solution:

An instrument that combines He^3-filled proportional counters with solid-state detectors to achieve the properties of high efficiency, good resolution, rapid response, and effective gamma-ray rejection.

How it's done:

Using the He^3(n,p)T reaction as a neutron converter, if the total energy of the secondary particles, the proton and triton, is absorbed, the recorded spectrum is easily interpreted. Since this reaction has a Q-value of 0.760 Mev, the energy of a recorded neutron is well above most background (interference), and a resolution of 30 to 50 Kev can be achieved. Neutrons whose absolute energies are 2 to 3 times this value (as low as 100 Kev), produce peaks that can be resolved from those peaks produced by thermal neutrons. A number of advantages are realized if a method that makes use of the volume of He^3 gas present in the solid-state sandwich spectrometer is developed. The He^3 gas is used as a proportional counter. Resolution is improved by adding the energy deposited in the proportional counter to that absorbed in the solid-state charged-particle detectors. Coincidence between the solid-state detector and the proportional counter results in greatly reduced background.

An extension of the above use of He^3 gas as a proportional counter, is to divide the volume into two proportional counters. This arrangement permits the use of particle identification techniques to eliminate gamma interactions, He^3 recoils, deuterons from the He^3(n,d)D reaction, alpha particles from the Si^{28}(n,a)Mg^{25} reaction, and many of the protons from the Si^{28}(n,p)Al^{28} reaction.

A neutron spectrometer has been developed to incorporate the above considerations. The He^3 volume is divided into two proportional counters separated by a series of wires that defines the electric field. Coincidence between the two proportional counters is achieved, and a proton is identified through its (dE/dX) xE product.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10555

Patent status:

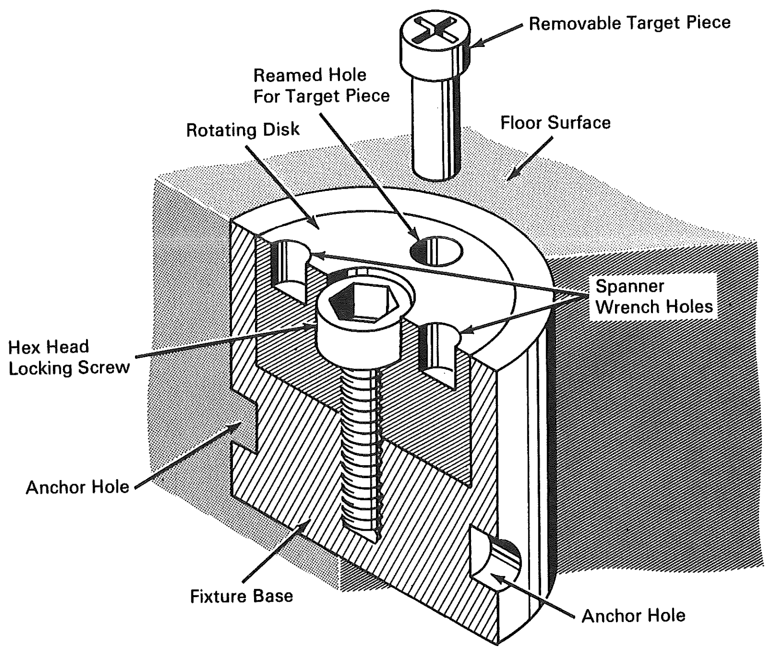
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Christopher C. Preston
and Robert B. Moler
of IIT Research Institute
under contract to
Marshall Space Flight Center
(M-FS-1664)

Category 01

NASA TECH BRIEF

Simplified Fixture Permits Precision Alignment of an Optical Target



The problem:

To provide an optical target holder that is permanently placed for instrument sighting, yet is adjustable and easily aligned. Standard alignment procedures require expert skill in the sighting and scribing of metal plates secured to stationary mountings. Because of the difficulty to align accurately, repeated attempts may be required. Floor settling or action of vibrating sources also cause misalignment over a period of time. Periodic realignment of fixed optical targets is costly and time consuming.

The solution:

A simple, permanently placed fixture for an optical target that is adjustable and easily calibrated.

How it's done:

The figure shows a commercially available target piece peg-mounted in a rotating disk of the fixture. The fixture is permanently mounted with the top slightly recessed and coarsely aligned to the point required by the sighting instruments. The disk is rotated by a spanner wrench positioning the target piece to the station defined by the optical instruments. The setting is locked by tightening the center screw and the target piece is then used for equipment alignment and removed when not in use. The fixture retains the same setting until the time of the next verification check when it may be easily recalibrated in the same manner.

(continued overleaf)

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10556

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D. C. 20546.

Source: P. Magura
of International Business Machines Corp.
under contract to
Marshall Space Flight Center
(M-FS-1181)

November 1966 Brief 66-10566

NASA TECH BRIEF

Computational Procedure for Finite Difference Solution of One-Dimensional Heat Conduction Problems Reduces Computer Time

The problem:

In solving ablation problems for which the mathematical model chosen to describe the ablation process is involved and/or for which the boundary conditions are not simple, numerical methods are usually employed. One of the most popular numerical techniques used for solution of this type of problem is the method of finite differences. Although this method is extremely powerful, in the practical use of this technique the economics (high computer-time cost) of problem solution is still a factor of consideration.

The solution:

A computational procedure for reducing the numerical effort whenever the method of finite differences is used to solve ablation problems for which the surface recession is large relative to the initial slab thickness.

How it's done:

A computational procedure for the finite difference solution of one-dimensional heat conducting problems with surface recession is particularly suited for problems in which the surface movement is large relative to the initial slab thickness and for which numerous time steps are involved. For definiteness, the problem of an ablating slab has been chosen; however, the method is not restricted to this specific problem. The finite difference scheme selected is arbitrary, although reference is made to the standard forward (explicit) differencing method and to the mid and backward (implicit) differencing schemes. The primary advantage in this computational procedure is in the reduction of the number of numerical operations required for a given maximum space mesh size, with smoothness retained at the moving surface.

Notes:

1. To establish the relative effectiveness of the computational procedure, a representative problem was chosen and run on the IBM 7094. The initial slab thickness was 1.000 inch, and the final thickness was calculated to be 0.327 inch. The rate of surface recession was 0.00096 inch per second during the 700 second heating period, and a cooling (soak) interval of 400 seconds, immediately following the heating period, was then considered. Two cases were run for comparison purposes. The first case consisted of starting with 20 ablator and 7 substructure mesh points and ending with the original number of points. The second case started with the same 27 mesh points but ended with 14 points and used an interpolated value of temperature routine. The same calculation interval (time mesh size) was used for both cases. Excluding the cost for reading in data and for printing results, the cost of case two was 21 percent less than that of case one. The cost of reading in data and for printing was 48 percent of the total cost. Although this specific example cannot be generalized to all cases, it does, however, give some indication as to the effectiveness of the procedure for solution of problems of this type,

(continued overleaf)

2. Further information concerning this invention is given in "A Computational Procedure for the Finite Difference Solution of One-Dimensional Heat Conduction Problems with Surface Recession," by H. T. Iida, Report No. SID 65-1252, North American Aviation, Inc., November 1965. Copies may be obtained from:

    Technology Utilization Officer
    Manned Spacecraft Center
    Houston, Texas 77058
    Reference: B66-10566

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: H. T. Iida
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-1120)

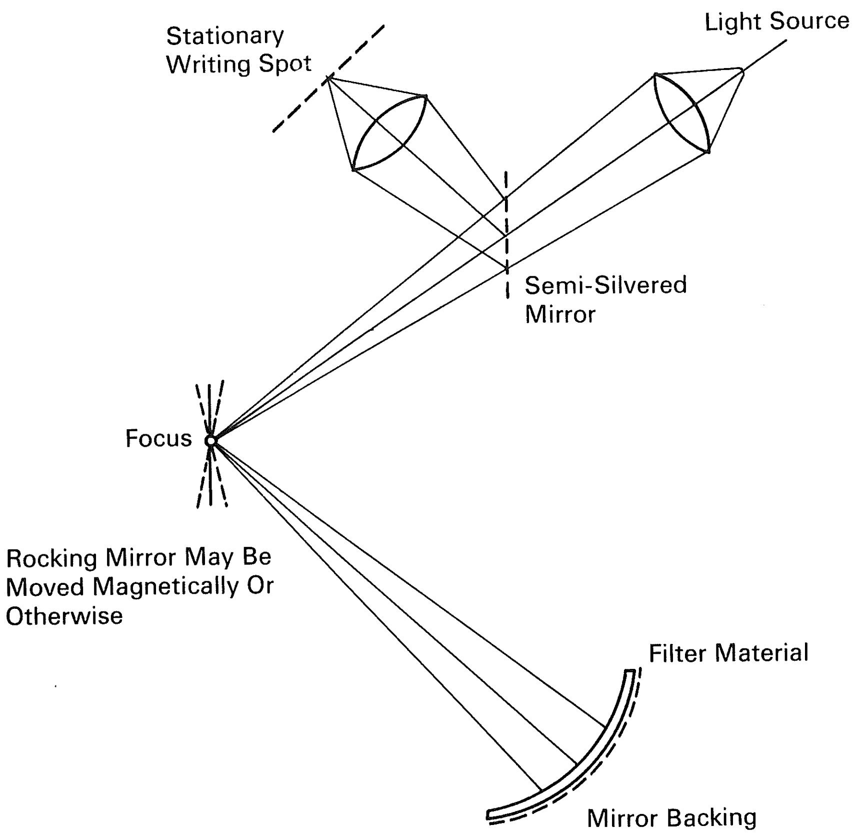
December 1966

Brief 66-10476

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Device To Color Modulate a Stationary Light Beam Gives High Intensity



The problem:

To color modulate a beam of light while also providing high intensity and a stationary beam, either collimated or focused. It is desirable in systems where color modulation of light is employed to transmit signal information to provide a stationary color modulated output beam in order that the signal information may be utilized without compensating for output beam movement. One method of providing such a stationary output beam employs slitted apertures which compensate for the dispersion of light inherent in prismatic or grating light refraction. However, the small slitted apertures required in such systems limit the intensity of the output beam of light too greatly for many applications.

(continued overleaf)

The solution:

An improved signal controlled system for the color modulation of a beam of light in which the color shift for given signal variations is predetermined and may be varied as desired. A beam of light is directed through filters of the desired color according to the position of an oscillating mirror from which the beam is reflected.

How it's done;

A beam from a concentrated white-light source is focused onto a mirror that can be oscillated at any desired modulation frequency. The light reflects from this mirror to a set of colored filters so arranged that as the beam oscillates, it passes through the different colors according to a predetermined modulation pattern. A concave mirror behind the filters returns the light to the oscillating mirror, back to a beam divider and then to the output point.

Notes:

1. The feasibility of recording a beam of light which has been color modulated by prismatic or grating type refraction in conventional three color film is complicated by the color response of the film being incompatible with the color blending and the color dispersion inherent in prismatic color modulation. The color modulation acquired by the presented system can be compatible with any color film by employing color filters formed to provide a color wedge having a color distribution compatible with the film's color sensitivity.
2. This color modulator system may also be applicable for color separation work in the graphic arts.

Patent status:

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)) to the Regents of the University of California, 2200 University Avenue, Berkeley, California 94720.

Source: William A. Gantz
of University of California
under contract to NASA
(Hq-44)

December 1966

Brief 66-10524

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Study of Vortex Valve for Medium Temperature Solid Propellants

The fluid state vortex valve secondary injection control system shows considerable promise for future application to solid propellant rocket engine thrust vector control. The single axis injection system tested would be capable of providing secondary injection thrust vector control using 2000°F gas.

The following summarizes the program's activities:

Six hot-gas firings were made. The gas generator supplied a flow of 1.0 lb/sec for 30 seconds. This system incorporated two vortex valves in parallel, functioning together as a flow divider circuit. One of the vortex valves utilizes active control, the other acting essentially as a pressure regulator maintaining the supply pressure constant by effectively bypassing flow when the power valve is throttled. This system demonstrated a flow modulation capability in excess of 4 to 1. The particular system concept selected, using active control on only one vortex valve, does not produce the desired total system performance. A better system approach would be to use active control on both vortex valves and operate essentially in a push–pull mode. The system dynamic response was evaluated with sinusoidal and transient inputs. At 30 cps the amplitude attenuation was −4db and the phase lag was 28 degrees. The frequency response of the basic vortex valve is fast enough so that the system dynamics are dominated by the associated manifold volume compressibility time constants.

The control system components and associated hardware functioned as desired. The performance of the vortex valve did not change during a 30-second hot-gas test, indicating insensitivity to thermal expansion. A composite structure of high density graphite backed with asbestos-phenolic eliminated erosion in the supply manifold.

Cold gas testing of a one-sixth scale model vortex valve was conducted to optimize the configuration and performance of the vortex power valve and vortex regulator valve for the selected system. The normalized performance, with regard to gains and flow modulation range, was practically identical for hot- and cold-gas tests. The two vortex valves required complementary characteristics, achieved by variation in the vortex valve geometry. This parameter variation experience resulted in further insight into the basic knowledge of vortex valve technology and control system performance.

The logical extension of this program is to develop a fluid state control system using high temperature (6000°F) aluminized solid propellant gases. Eventually, a direct engine bleed, fluid state, secondary injection thrust vector control system should provide a lightweight system with inherent simplicity and high reliability.

Note:

Additional information is contained in: "Research Study of the Vortex Valve for Medium-Temperature Solid Propellants," by W. D. Holt and J. G. Rivard, The Bendix Corporation, August 1965, Report No. N66-21695, which may be obtained from:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia 23365
Reference: B66-10524

(continued overleaf)

Patent status:

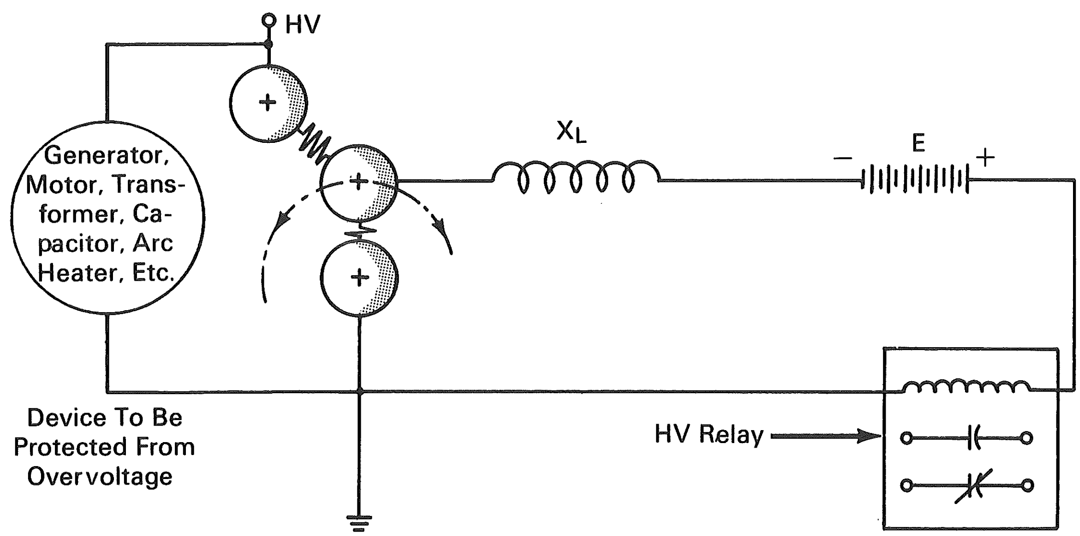
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: W. D. Holt and J. G. Rivard
of The Bendix Corporation
under contract to
Langley Research Center
(Langley-204)

December 1966 Brief 66-10557

NASA TECH BRIEF

Trisphere Spark Gap Actuates Overvoltage Relay



The problem:

To provide a positive, fast response, high current capacity device that will sense an overvoltage condition and remove power from the circuit before insulation breakdown.

The solution:

A trisphere spark gap and high voltage relay so arranged that when an overvoltage occurs, the spark gap breaks down and conducts an actuating current to the relay which removes power from the circuit.

How it's done:

Three 1 1/4-inch copper spheres are mounted on 1/4-inch brass rods to a section of dielectric material. The center sphere is located in relation to the grounded sphere so that a constant 1/8-inch gap is maintained between them, while spacing between the center and high voltage spheres may be varied. Connected in series between the center and grounded spheres are a high voltage relay, a battery and a small choke coil.

When the high voltage sphere (which is integral to the circuit being protected) reaches a predetermined potential, the gaps will break down and current will flow between the three spheres. Because of the choke in the relay circuit, both gaps will break down simultaneously and the ionized path between the center and grounded spheres completes the relay circuit and energizes the relay. The relay contacts remove the source of high voltage to the protected circuit and the trisphere spark gap/relay device is automatically returned to its passive condition.

(continued overleaf)

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: B66-10557

Patent status:

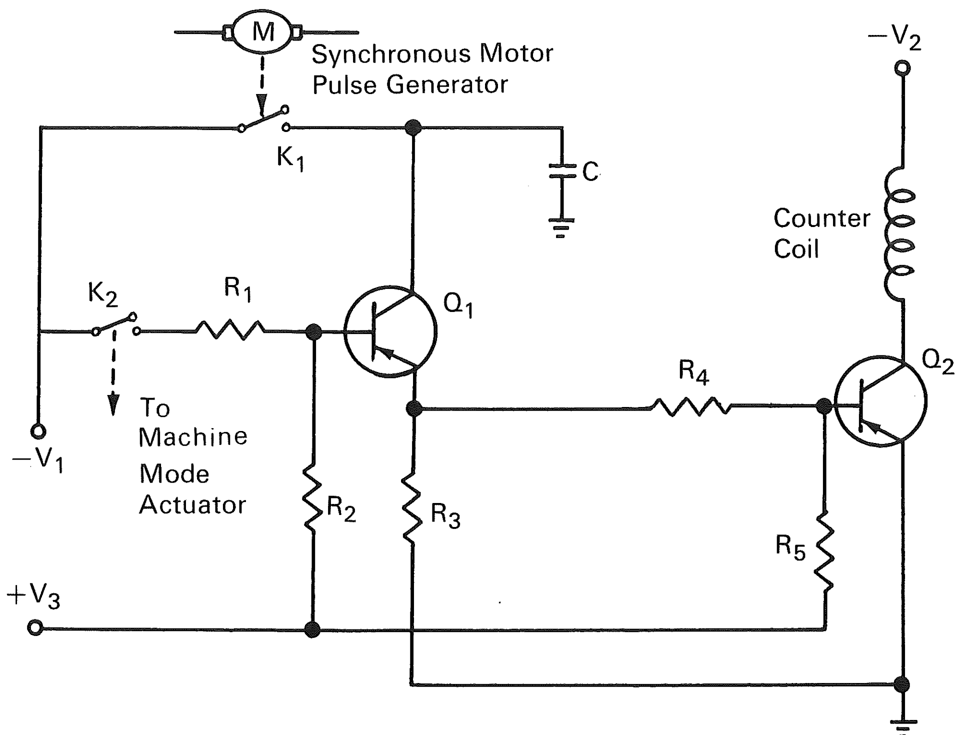
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Salvador L. Camacho
(ARC-68)

December 1966 Brief 66-10559

AEC-NASA TECH BRIEF

One-Count Memory Circuit Prevents Machine Mode Interaction



The problem:

To design an inexpensive one-count memory logic circuit to be used with electromechanical counter–printer machines which operate in either count or print mode. While the machine is in the print mode, it is desirable that the counter not be actuated to interfere with the printing process. Should a count pulse occur while the machine is in the print mode, the pulse must be stored and then transmitted as soon as the printing stops and the machine switches back to the count mode.

The solution:

A one-count memory logic circuit that advances the counter when the machine is in the count mode and provides storage for the count pulse when the machine is in the print mode. As soon as the printout is accomplished, the circuit releases the stored count pulse, and the counter advances.

How it's done:

Q_1 and Q_2 are initially biased in the nonconducting region by R_2 and R_5. The count pulse is generated by means of a synchronous motor-driven pulse generator

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which closes the contacts of K_1 for approximately 40 milliseconds once every minute. The contacts of K_2 are controlled by the mode of the machine.

When the machine is in the count mode, K_2 is closed. As K_1 closes, a count pulse of magnitude $-V_1$ turns Q_1 "on" driving the emitter negative. The negative emitter voltage of Q_1 saturates Q_2, allowing current to flow through the counter coil and to advance it one position.

When the machine is in the print-out mode, K_2 is open and Q_1 is biased "off". Should K_1 close while Q_1 is biased "off", the count pulse will charge the storage capacitor, C, to the value $-V_1$. As soon as the machine returns to the count mode, causing K_2 to close, Q_1 will turn "on" and C will discharge through Q_1, saturating Q_2 and advancing the counter one position.

Note:

Inquiries concerning this innovation may be directed to:

Office of Industrial Cooperation
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439
Reference: B66-10559

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

Mr. George H. Lee, Chief
Chicago Patent Group
U.S. Atomic Energy Commission
Chicago Operations Office
9800 S. Cass Avenue
Argonne, Illinois 60439

Source: B. De Forest,
Idaho Division
(ARG-90)

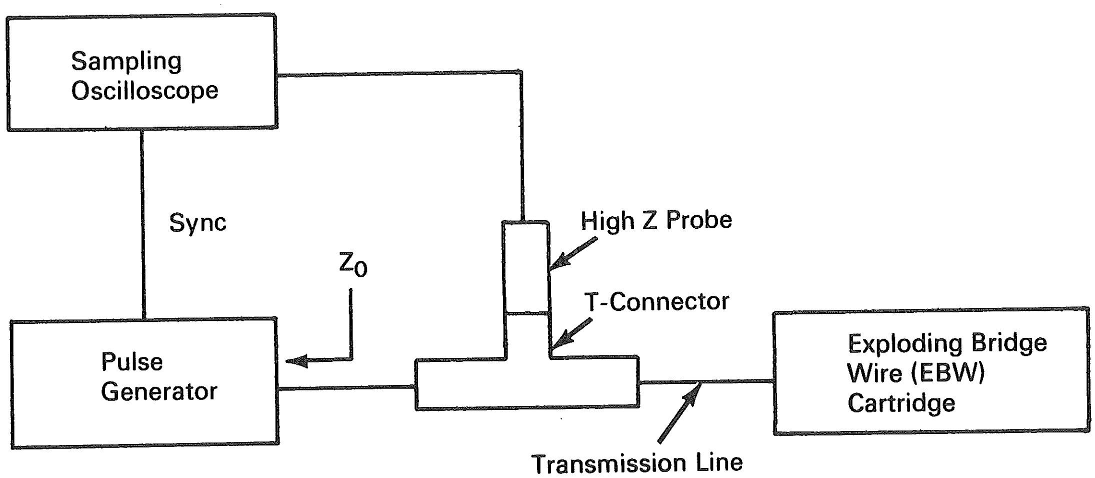
December 1966

Brief 66-10561

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Pulse Technique Provides More Accurate Checkout of Exploding Bridge Wire Device



The problem:

To develop a more dependable method for checking the electrical integrity of an Exploding Bridge Wire (EBW) cartridge. In many exploding bridge wire ordnance devices there is a spark gap in series with the exploding bridge wire. The spark gap makes it difficult to check out the device. Presently there are two methods used to test EBW cartridges: an ac continuity check, and a dc spark-gap breakdown voltage and continuity checkout. Both of these test methods are attempts to validate the electrical integrity of the EBW cartridge, but both methods indicate only gross circuit parameters.

The solution:

Treat the EBW as a transmission line system and use pulse reflection techniques. Propagate a step voltage into the system and monitor the reflected voltage waves.

How it's done:

Pulse reflection testing employs a step generator and an oscilloscope in a manner that is similar to a radar system. A voltage step is propagated into the test setup and the reflected waves are monitored. The echo technique reveals both the position and the nature (resistive, inductive, or capacitive) of each discontinuity along the system. As shown, the pulse reflection measuring system consists of a fast rise time pulse generator to drive the EBW cartridge and transmission line and a fast rise time oscilloscope to display the reflections. No complicated directional couplers are needed to separate the incident and reflected waves.

(continued overleaf)

Note:

Inquiries concerning this invention should be directed to:

Technology Utilization Officer
Headquarters
National Aeronautics and Space Administration
Washington, D.C. 20546
Reference: B66-10561

Patent status:

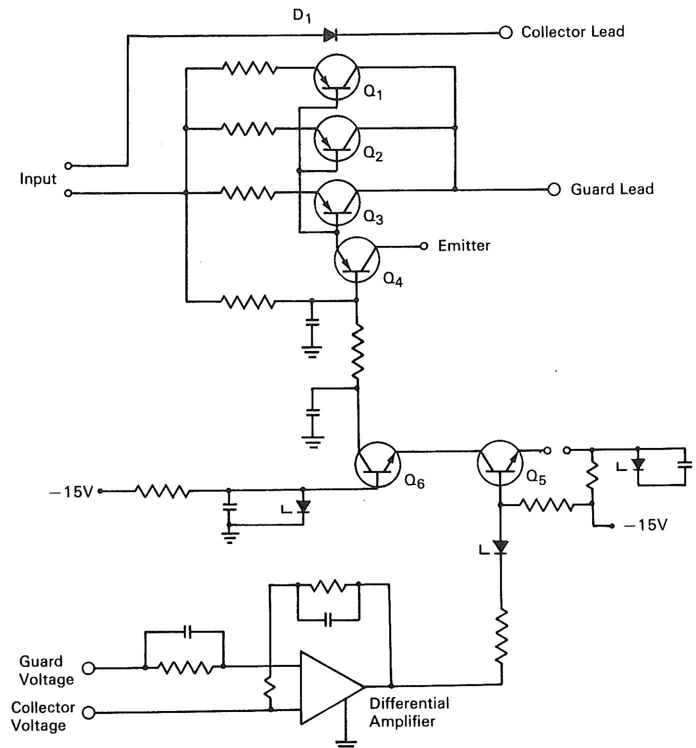
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. R. Petrick
of General Electric Company
under contract to NASA
(Hq-62)

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Collector/Collector Guard Ring Balancing Circuit Eliminates Edge Effects



The problem:

One of the problems in thermionic converters involves the use of plane parallel electrodes. A guarded electrode arrangement is required to eliminate edge effects.

The solution:

A circuit in which an emitter is maintained opposite a concentric collector and guard structure. In this arrangement effective guarding is achieved by matching the temperature and potential of the guard with that of the collector over the operating range.

How it's done:

The three pass transistors, Q_1, Q_2, and Q_3, control voltage drop in the guard lead to balance that in the collector lead. Diode D_1 in the collector circuit ensures that sufficient voltage is maintained across Q_1, Q_2, and Q_3 to keep them out of saturation. Q_1, Q_2, and Q_3 and D_1 also act to block the reverse current portion of the sweep. These are mounted on a water-cooled heat sink to dissipate the appreciable power involved in their operation. Q_4 is a driver transistor and uses the sweep voltage as a power source. The differential amplifier senses any imbalance at the

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voltage leads and, after amplification of Q_5 and the isolation provided by Q_6 (a common base stage), input to the differential amplifier reduces oscillations due to feedback.

Notes:

1. Connected to a converter, balance within 10 mv was obtained except near the ignition point where there were some small oscillations that were not visible on an actual J-V plot. At high currents the system was stable and no oscillations were present.
2. This control system is capable of handling up to 100 amperes in the guard circuit and 200 amperes in the collector circuit.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10563

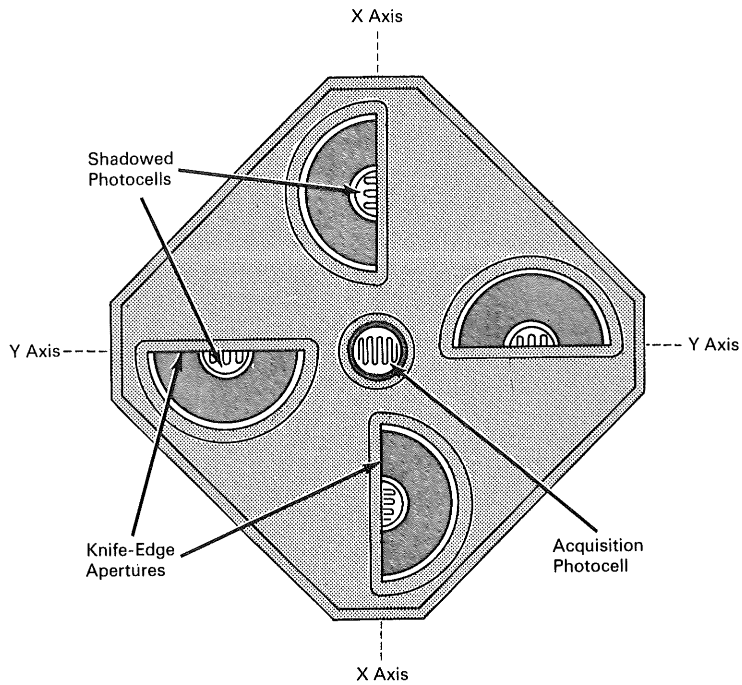
Patent status:

No patent action is contemplated by NASA.

Source: David P. Lieb
of Thermo Electron Engineering Corporation
under contract to
Jet Propulsion Laboratory
(JPL-SC-143)

NASA TECH BRIEF

Photocell Shadowing Technique Improves Light Source Detector



The problem:

To design a light source tracking detector that exhibits minimum scale factor change with increased light source angle. The tracking detector should be simple in construction and use standard, reliable components.

The solution:

A lightweight, compact modular system that includes an acquisition photocell for seeking the light source and four shadowed photocells, two per (X and Y) axis.

How it's done:

Operation of the tracking detector involves null sensing by two sets of two cadmium sulfide photocells operating in an X-Y configuration to act on a bridge circuit. These four cells are shadowed by knife-edge apertures that cause one cell in an axis to receive more luminous flux than the other as a function of tracker angular displacement. This results in an electrical offset in the bridge circuit proportional to the degree of angular displacement. A fifth, or acquisition cell, mounted in the center of the module, operates in conjunction with a switching circuit to provide an acquire

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and intensity signal to discriminate between wanted and unwanted sources. Using two cells in each axis with opposite shadow edges, angular motion of the light source causes one cell to increase in resistance while the opposite cell resistance decreases, thus causing a positive or negative voltage output in the bridge circuit. This output signal is processed to produce a dc output error signal that operates a servo system to return the detector to a null position by removing the pointing error.

Notes:

1. The bridge circuit plus signal processing electronics are packaged in the back portion of the tracker, thus making a small, lightweight unit.
2. Photocells of various types, responsive to other portions of the spectrum, could be used to acquire and track infrared, ultraviolet, and other source fluxes.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10564

Patent status:

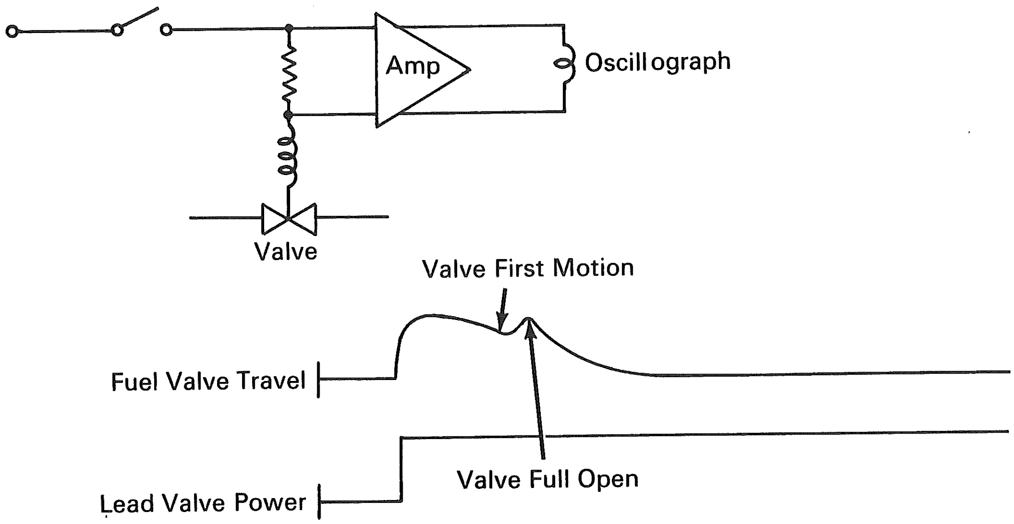
No patent action is contemplated by NASA.

Source: Gerald E. Hooper
and Dennis G. Carpenter
(JPL-809)

December 1966 Brief 66-10568

NASA TECH BRIEF

Monitoring Circuit Accurately Measures Movement of Solenoid Valve



The problem:

To accurately measure the valve travel of solenoid operated valves, which are generally hermetically sealed. Valve opening times can be established only by inference from the rate of change of the pressure levels in various portions of the fluid system in which they are employed. When such valves are used for metering or critical operational sequencing, inferred values of travel time are not sufficiently accurate for reliable control, due to the influence of system volume and pipe size on the rate of change of pressure.

The solution:

A solenoid operated valve in a control system powered by direct current. The valve travel can be reliably monitored through accurate measurement of the rate of change of the solenoid operating current. This current level is a direct function of the position of the solenoid armature in relation to the coil. Absolute values of current will be found to vary over a wide range; however, the characteristic shape of the current vs time plot is found to be similar for practically all dc solenoids.

How it's done:

A small resistor with sufficient capacity to match the solenoid maximum current requirement is inserted in series with the solenoid coil. The voltage drop across this resistor is the input to a solid-state amplifier. The amplifier output drives a galvanometer in a recording oscillograph operating at approximately 10 inches/second. By recording several valves on the same oscillograph, both valve opening time and sequence of operations are critically measured.

Notes:

1. This system is currently in operation with a 28-vdc power system used for control of fluids in liquid rocket motor test facilities. In this application, the the sequencing of various flows is critical to the ±10-millisecond level.

(continued overleaf)

2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10568

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. D. Gillett
of North American Aviation Inc.,
under contract to
Marshall Space Flight Center
(M-FS-1829)

December 1966 Brief 66-10569

NASA TECH BRIEF

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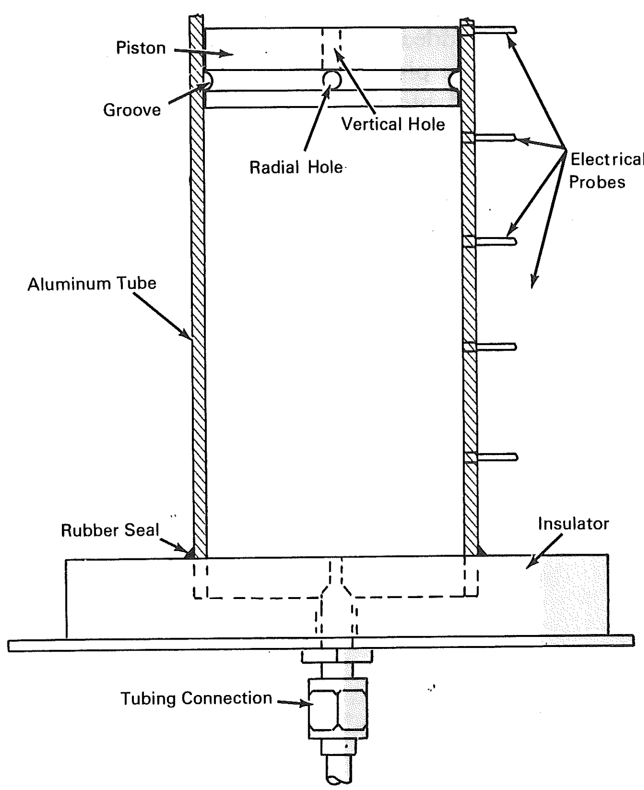
Device Accurately Measures and Records Low Gas-Flow Rates



The problem:

To design a device that will accurately measure and record low gas-flow rates. The device must provide an accurate and directly inked record of flow rates such as leaks at valve packings and seals.

The solution:

A free-floating piston in a vertical column. The principle of operation is similar to that of an industrial gas-holder, which provides a varying volume at constant back pressure. As the piston rises in the column, the mercury in the seal makes and breaks contact from the probe to the aluminum of the column as it passes each probe level. The probes are connected to recorder pins.

How it's done:

The column is a seamless aluminum tube of selected diameter. The inner surface accuracy of the tubing has been improved by forcing a 0.002 oversize mandrel through its length. The piston is machined from Mylar. The outer diameter of the piston is sized for a

(continued overleaf)

sliding fit, so that it will glide down the open column quite readily, but will sink very slowly if the column is closed at the bottom. To provide an effective seal, or ring, for the piston, a ring groove is machined around the outer circumference. Four holes drilled radially connect the ring groove to a vertical hole drilled at the piston centerline.

The piston is inserted in the column and mercury is poured in the center hole until it rises even with the top of the piston. The mercury flows through the 4 radial holes, filling the groove with mercury. Since the mercury cannot "wet" the aluminum of the column, it will be retained in the groove under normal conditions, thus providing an effective seal.

To provide a signal for the recorder a row of insulated electrical probes are cemented in one side of the cylinder. The points of the probe are exactly flush with the inner surface of the column and studded on the outer end for electrical connection. As the piston rises in the column, the mercury makes and breaks contact from the probe to the aluminum of the column as it approaches each probe level. The upper probe is used as a limit switching point for automatic recycling. The probes are connected to recorder pins.

Notes:

1. The system may be calibrated, using an adjustable flow-rate gas supply, a low pressure gage, and a sequence recorder. From the calibration rates, a nomograph may be made for easy reduction. Temperature correction may be added for further accuracy.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10569

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: L. W. Branum
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center

(M-FS-1077)

December 1966 Brief 66-10574

NASA TECH BRIEF

Nondestructive Test Method Accurately Sorts Mixed Bolts

The problem:

To develop a nondestructive test method of sorting copper plated steel bolts from nickel plated steel bolts. Large quantities of steel bolts had been received from vendors for installation on the Saturn IC stage. A portion of these bolts were copper plated and then cadmium plated; the others were nickel plated and then cadmium plated. Laboratory environmental corrosion tests indicated that the copper subplate was deleterious and presented a serious corrosion problem. Corrosion could occur if there were cadmium discontinuities, porosity, surface breaks, scratches, cuts, etc. All bolts presented a very similar appearance. Various X-ray techniques including absorption, backscatter, etc., were tried but were unsuccessful.

The solution:

A method using neutron activation analysis. Copper and nickel plated steel bolt specimens of the same configuration are irradiated with thermal neutrons in a test reactor for a short time.

How it's done:

After thermal neutron irradiation, the bolts are analyzed using scintillation energy readout equipment. The bolts having copper plating show a copper peak at 0.51 Mev as distinguished from Ni at 0.848 Mev.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10574

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

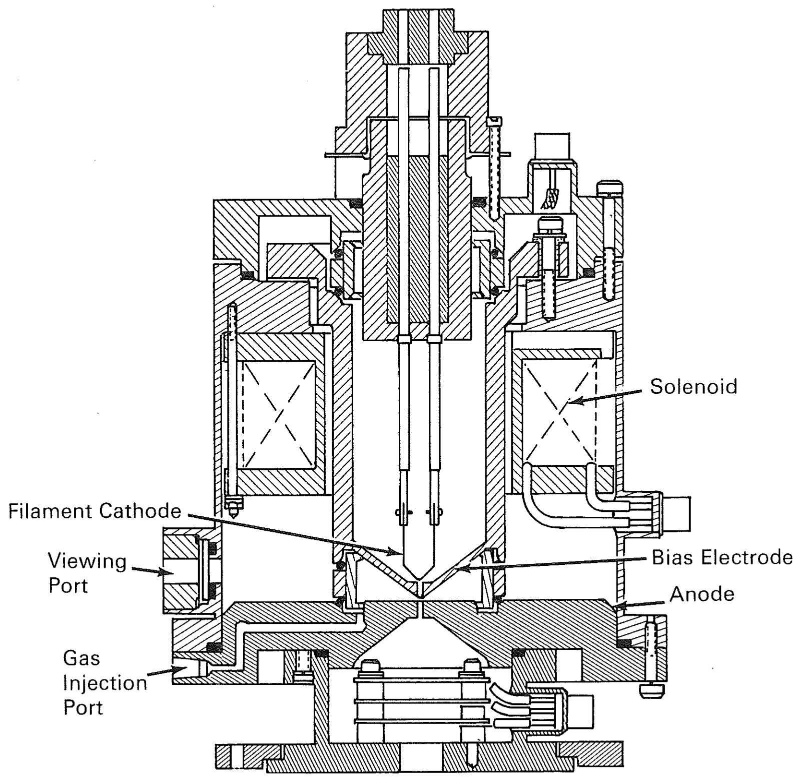
Source: C. J. Dezeih
(M-FS-1426)

Category 01

December 1966 Brief 66-10576

NASA TECH BRIEF

A Continuously Operating Source of Vacuum Ultraviolet Below 500 Å



The problem:

To develop a continuously operating source of ultraviolet radiation in the wavelength region between 10 and 1,000 Å. Present devices are so large (with energetic arc columns to 6 foot length) as to be inconvenient as laboratory tools.

The solution:

A duo plasmatron type source that is a modification of the Von Ardenne duo plasmatron. The source produces spectral lines below 500 Å in a helium environment, measured by a 1/2-meter, grazing incidence spectrometer.

How it's done:

The magnetic components, anode, bias electrode, and that portion of the outer chamber between these two electrodes are of soft iron. A solenoid of 1,000 turns of #18 copper wire produces the necessary magnetic field. The nose cone of the bias electrode saturates first in the magnetic circuit. This saturation

(continued overleaf)

occurs at about 12,000 gauss, being induced by a solenoid current of 2 amperes. This produces a magnetic field of about 7,000 gauss between the bias and anode electrodes. The bias electrode placed between the cathode and anode has a small aperture at its apex to restrict the arc.

The duo plasmatron design creates a magnetic mirror field in the region of high ion density and acts to reflect the electrons so that escape is possible only very near the axis. The arc is thus caused to draw down to a very small conical envelope coming to a point at the anode where ion densities of 6×10^{14} ions/cm^3 occur.

Helium is used for spectral line investigation and is introduced to the area of the ionizing arc through an injection port in the source body. The point source is located 5 cm from the entrance slit of the grazing incidence spectrometer.

Notes:

1. Because the spectra produced are determined almost completely by the gas injected, and because the source operates continuously, this arrangement should be beneficial in the development and calibration of filters and detectors within discrete wavelength ranges.
2. The duo plasmatron source has produced high ion densities from relatively low power input and the entire source assembly occupies a volume of only 100 cubic inches.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: B66-10576

Patent status:

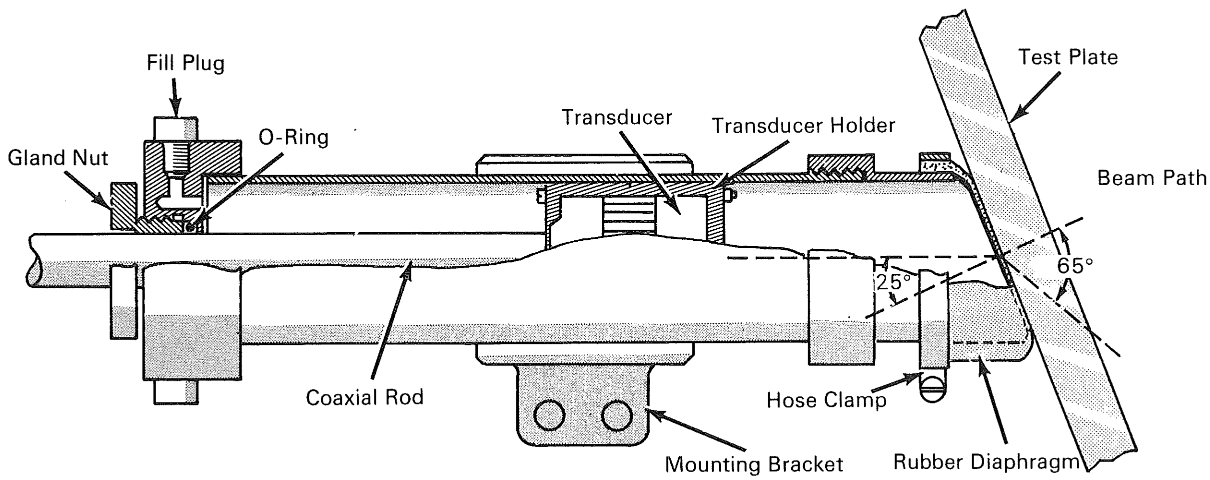
No patent action is contemplated by NASA.

Source: Space Sciences Incorporated
under contract to
Goddard Space Flight Center
(GSFC-545)

December 1966 Brief 66-10577

NASA TECH BRIEF

Ultrasonic Water Column Probe Speeds Up Testing of Welds



The problem:

To devise a method, incorporating ultrasonic methods, to speed up the testing of welds. In testing the Saturn IC tank welds, a manual testing operator could test about 12 feet an hour, or take about 12 hours to test 1 of the circumferential welds. The size of the Saturn IC tanks precluded the use of any of the immersion testing methods. The commercially available wheel ultrasonic probe was not satisfactory because it could not be used at the desired test beam angles.

The solution:

An ultrasonic device consisting of a coaxial rod and transducer enclosed in a cylindrical probe which is filled with de-ionized or distilled water. A rubber diaphragm is molded to produce the desired test beam angle.

How it's done:

The water column probe contains the water and a beam transducer that can be focused to a desired point in the material by moving the transducer to various levels. A transducer holder acts as a spacer and maintains the position of the transducer after setting; filler caps maintain the water level. The rubber diaphragm is the contact surface of the probe, and retains the water in the column. The thin membrane on the face of the diaphragm is flexible enough to allow full contact with slightly rough or curved surfaces, and can be moved close to a high weld bead.

Notes:

1. The water column probe is not as thorough for testing welds as the manual techniques. The advantage is in making a quick scan of the weld. Until greater confidence is gained based on production experience, the manual test should be used as a backup check on indications and to provide more depth and defect type information.

(continued overleaf)

2. Inquiries concerning this invention should be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics and Space Administration
   Washington, D.C. 20546
   Reference: B66-10577

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. M. Hoop and J. A. McDonald
of the General Electric Co.
under contract to
NASA Headquarters
(Hq-58)

December 1966 Brief 66-10579

NASA TECH BRIEF

An Orthonormalization Procedure for Multivariable Function Approximation

The problem:

In many types of scientific and engineering problems, a table of two or more columns of data occurs and it is often desirable to present this data in a more useful form. The usual methods for performing this task are the many different techniques of multivariable function approximation such as the least squares procedures that require appreciable time to compute the coefficients.

The solution:

Where a function of several variables is given numerically in tabular form, an orthonormalization technique allows an approximation of the numerical data to be determined in a convenient functional form. The method requires much less computational work than the usual least squares technique, and allows more easily controlled accuracy. In this technique, the speed and accuracy of coefficient computation are much improved. Additionally, a very clear and useful physical interpretation of the procedure is available to aid in the choice of terms to be included in the approximating formulas.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10579

Patent status:

No patent action is contemplated by NASA.

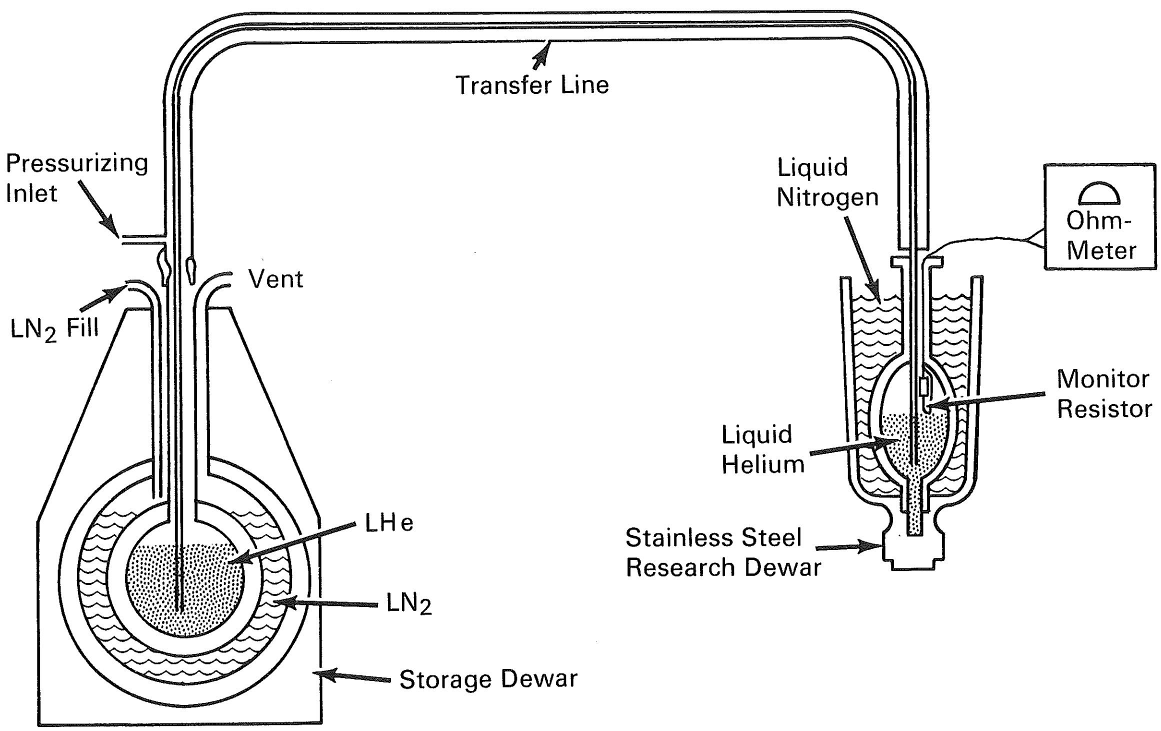
Source: Hugo L. Ingram
(M-FS-1313)

Category 01

December 1966 Brief 66-10580

NASA TECH BRIEF

Resistor Monitors Transfer of Liquid Helium



The problem:

To devise a means of distinguishing between the transfer of liquid helium and gaseous helium into a closed dewar.

The solution:

Use the large resistance change of a carbon resistor at the liquid helium temperature.

How it's done:

Attach a 1 Kohm resistor to the inner tube of the transfer line. The resistor should be physically as small as possible to reduce the heat load to the helium. Leads of No. 40 enameled wire or smaller should be attached to the resistor and connected to an ohmmeter for monitoring the resistance change. With liquid helium being transferred the resistance will be steady and approximately 100 Kohms. A transfer of gas will produce a reading below this maximum and the reading will fluctuate. The resistor may also be used to indicate a maximum or operating level of liquid in the research dewar and a minimum level of liquid in the storage dewar may be monitored by another such system in the storage dewar. The transfer of helium is discontinued by removing the pressure from the

(continued overleaf)

storage dewar. A falling resistance value indicates the level of liquid helium is below the resistor. A steady resistance indicates the level of the liquid is at or above the position of the resistor.

Note:

Information concerning this invention may be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia 23365
Reference: B66-10580

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: W. D. Hesketh
(Langley-229)

December 1966

Brief 66-10581

NASA TECH BRIEF

Detector Measures Power in 50 to 30,000 GHz Radiation Band

The problem:

To develop a broadband power measuring detector for electromagnetic radiation in the 50 to 30,000 GHz (6 mm to 10 micron) band.

The solution:

An assembly employing a matched pair of detectors which incorporate thin-film radiation absorbers.

How it's done:

Each of the two detectors in the assembly consists of a thin-film radiation absorber mounted on a dielectric substrate in close thermal contact with a thermistor bolometer element. The detectors are matched electrically and thermally to compensate for ambient temperature variations when operated in a balanced Wheatstone bridge circuit. In tests on an experimental model, the detector assembly exhibited the following characteristics at 70 GHz:

Responsivity	240 volts/watt
Minimum detectable signal	10^{-8} watt (approx. 1 sec)
Dynamic range	50 db (10^{-8} to 10^{-3} watt)
Output voltage	(Linear with respect to input power)

Notes:

1. The detector is effective with either coherent or incoherent radiation.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Electronics Research Center
   575 Technology Square
   Cambridge, Massachusetts 02139
   Reference: B66-10581

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: M. T. Wang and F. R. Arams
of Airborne Instruments Laboratory,
Cutler-Hammer, Inc.
under contract to
Electronics Research Center

(ERC-26)

Category 01

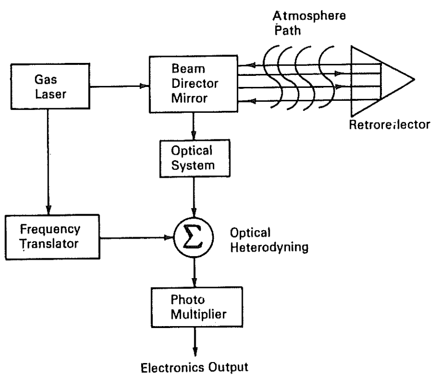
December 1966

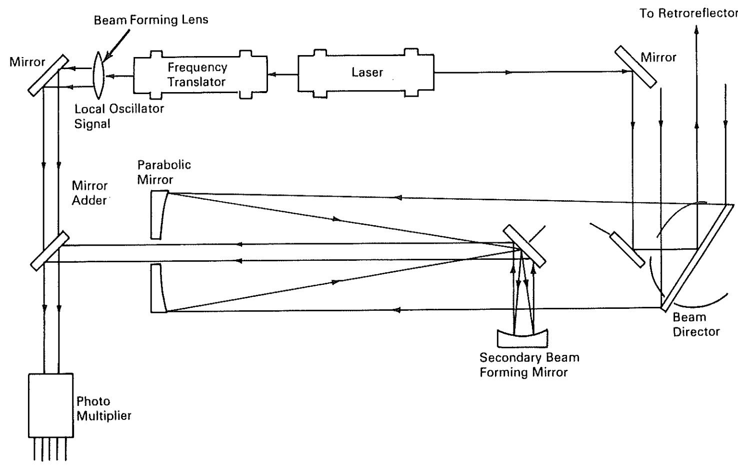
Brief 66-10584

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Optical Superheterodyne Receiver Uses Laser for Local Oscillator





The problem:

To develop an optical superheterodyne receiver to permit reception of amplitude modulated video bandwidth signals through the atmosphere.

The solution:

A system that uses a laser coupled to a frequency translator to supply both the incident signal and local oscillator signal in an optical superheterodyne receiver.

How it's done:

The output of the laser is reflected by mirrors to the beam director which directs it to the remotely located retroreflector. The return rays are reflected by the beam director to the parabolic mirror and then to the secondary beam forming mirror that directs the rays through the open center of the parabolic mirror to the mirror adder. Simultaneously, the local oscillator beam, originating in the laser is shifted in frequency by the frequency translator to provide a frequency offset. This offset beam is focused by a beam forming lens into a focus point corresponding to the focus point produced by the secondary mirror. The collimated return rays are now mixed with the local beam at the mirror adder and the resultant difference beat is detected by the photomultiplier and fed to the electronics output circuitry.

Notes:

1. A receiver than can cover a 1 gcs doppler range can be constructed with presently available components. Use of electro-optic frequency translators in conjunction with wideband detectors will make it possible to cover 20 gcs doppler shifts in the future.
2. This receiver should be useful in scientific propagation experiments, tracking experiments, and communication experiments.

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3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10584

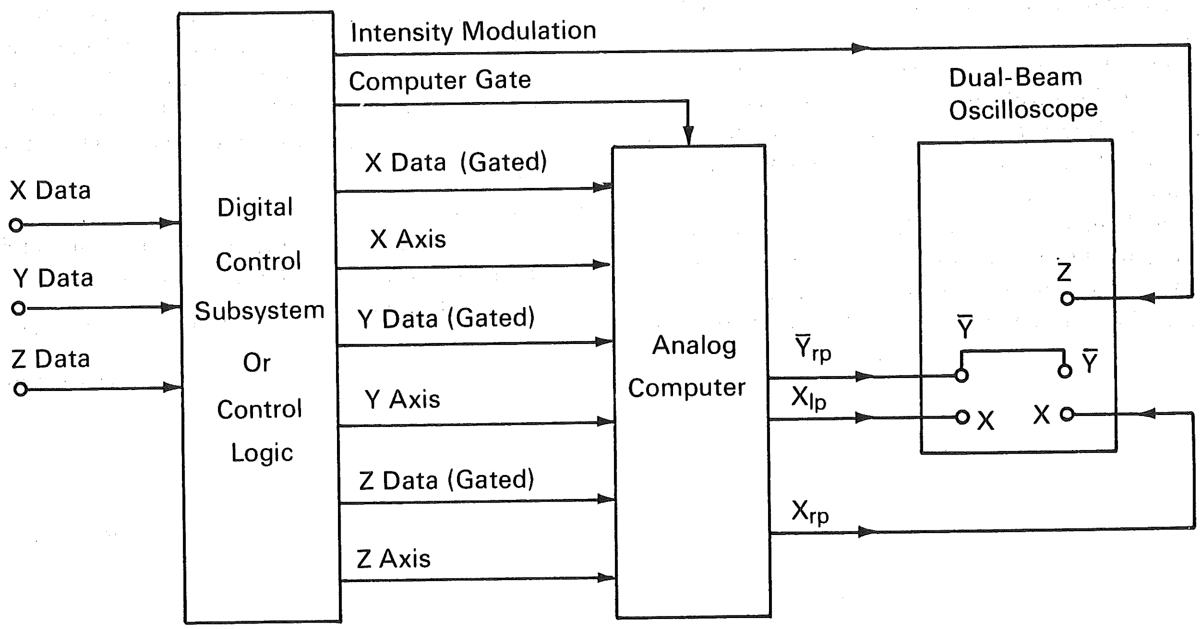
Patent status:

No patent action is contemplated by NASA.

Source: R. F. Lucy et al
of Sylvania Electronic Systems
under contract to
Marshall Space Flight Center
(M-FS-1605)

NASA TECH BRIEF

Study Made of Application of Stereoscopic Display System to Analog Computer Simulation



In system simulation, it is often desirable to present simultaneously several variables. Common display devices display only two variables. Some cathode-ray oscilloscopes provide for an external intensity-modulation input which increases to three the number of variables represented by a single trace. However, the intensity-modulated data is of qualitative nature and does not lend itself to quantitative measurement. It is useful to have a visual display system which provides both a qualitative and measurable presentation for functions of several variables.

A primary application of such a display system is in analog computer simulation of sets of differential equations. If the system with the aid of an oscilloscope and high iteration rate simultaneously presents three variables on a single display, then such data as roll, pitch, and yaw of a missile; range, azimuth, and elevation from a radar system; or position, velocity, and acceleration of a control system can be viewed at the same time. Gains, feedback, and/or compensation can then be adjusted while observing the effects of their change on the system operation. Since an analog

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computer is available for the simulation, the inclusion of certain computer functions as inherent elements of the display system is permissible.

The block diagram of a system capable of simultaneously displaying three variables is shown. When used with an optical adapter, it converts a normal dual-beam oscilloscope into a stereoscopic, three-dimensional viewing system. The intensity-modulation input can either be used to present qualitatively a fourth variable or to present a superimposed slow trace simultaneously with the fast trace (the fast trace, to appear stationary, has to be repeated at least 25 times per second).

The X, Y, and Z data inputs may be from any source, but should be restricted to frequencies compatible with the particular analog computer. For most applications, the data is generated within the analog computer, but it is easily visualized that data could come from a digital memory when, for example, displaying the spatial distribution of atoms in a complex molecule.

The digital control subsystem or control logic provides synchronization of the analog computer, intensity modulation signals for the oscilloscope, gating input data, and a set of coordinate axes for the oscilloscope display.

Certain elements of the analog computer are used to implement the projection and rotation equations. The latter allow the coordinate axes and the data display to be rotated to provide the observer with various perspective views. The analog computer outputs serve as inputs for the oscillloscope display.

Notes:

1. The X,Y,Z information does not have to come from the solution of a set of differential equations. The display can also be used to show spatial point distributions, surfaces, body outlines, etc. What can be shown is only limited by the operator's ingenuity (and equipment) of how to present all the X,Y,Z information repetitively more than 25 times per second.
2. A detailed description of the display can be found in IN-R-ASTR-65-7, "A Three-Dimensional Display", by H. F. Kennel, MSFC, March 12, 1965, which may be obtained from:
   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10590
3. A slightly different implementation, is described in NASA CR-61116, "A Steroscopic Display System," by D. W. Russell, Auburn University, Alabama, December 1965, which also may be obtained from the above Technology Utilization Office.

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: H. F. Kennel

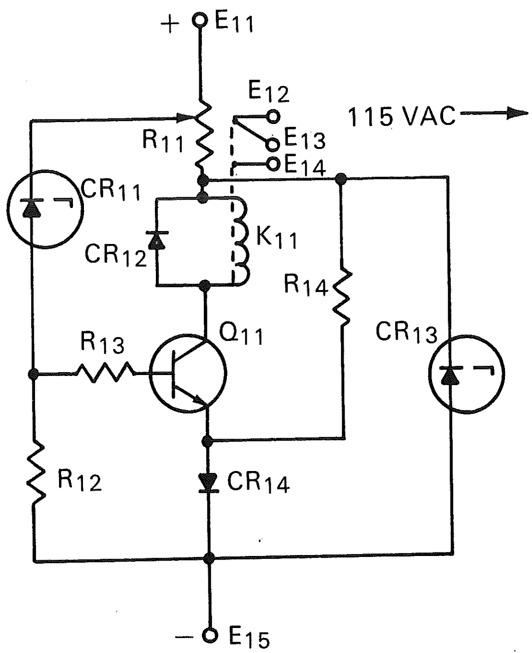
(M-FS-1263)

December 1966

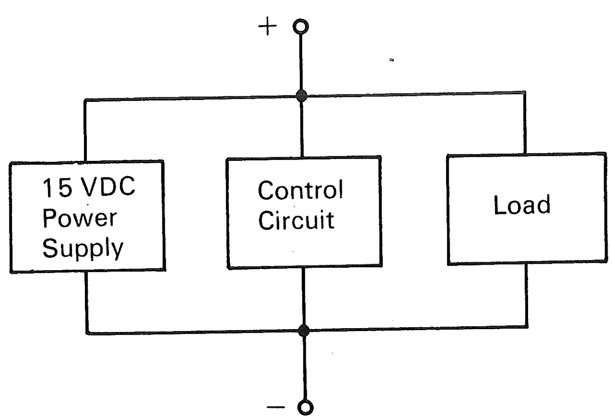
Brief 66-10591

AEC-NASA TECH BRIEF

Electronic Circuit Provides Accurate Sensing and Control of DC Voltage



Control Circuit



The problem:

To design an electronic circuit in which the current in the relay coil is held to zero for all input voltages up to slightly below the threshold level. A common method of sensing and controlling dc voltages is through the use of relay coils and amplifiers. The primary disadvantage of such a technique is that a current proportional to the sensed voltage is always in the relay coil, which tends to make the circuit susceptible to external disturbances such as electrical noise and mechanical vibrations.

The solution:

A circuit in which the control relay is driven by a switching transistor that is biased to cutoff for all input up to slightly less than the threshold level.

How it's done:

In the circuit shown, the control circuit is used to very accurately control the 15 volt, dc power supply providing power to the load. For an input voltage of 15, the zener diode CR_{13} will conduct and regulate the voltage to relay K_{11} and resistor R_{14}. A constant current will be maintained in diode CR_{14}. The forward

(continued overleaf)

voltage in CR_{14} will be at the same level as the emitter of switching transistor Q_{11}. R_{11} is adjusted so that zener diode CR_{11} does not conduct. Under these conditions the base of Q_{11} will be at zero volt. Q_{11} will be cut off and the voltage across K_{11} will be zero. As the input voltage increases above 15 vdc, CR_{11} will conduct and a potential difference (ΔV) will appear at R_{12}. When this potential difference exceeds the Q_{11} base-to-emitter voltage, current in Q_{11} will activate relay K_{11}. When K_{11} is activated, contacts E_{12} and E_{13} are broken which cuts off and locks out the 15 volt power supply controlled by the control circuit.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
AEC–NASA Space Nuclear Propulsion Office
U.S. Atomic Energy Commission
Washington, D.C. 20545
Reference; B66-10591

Patent status:

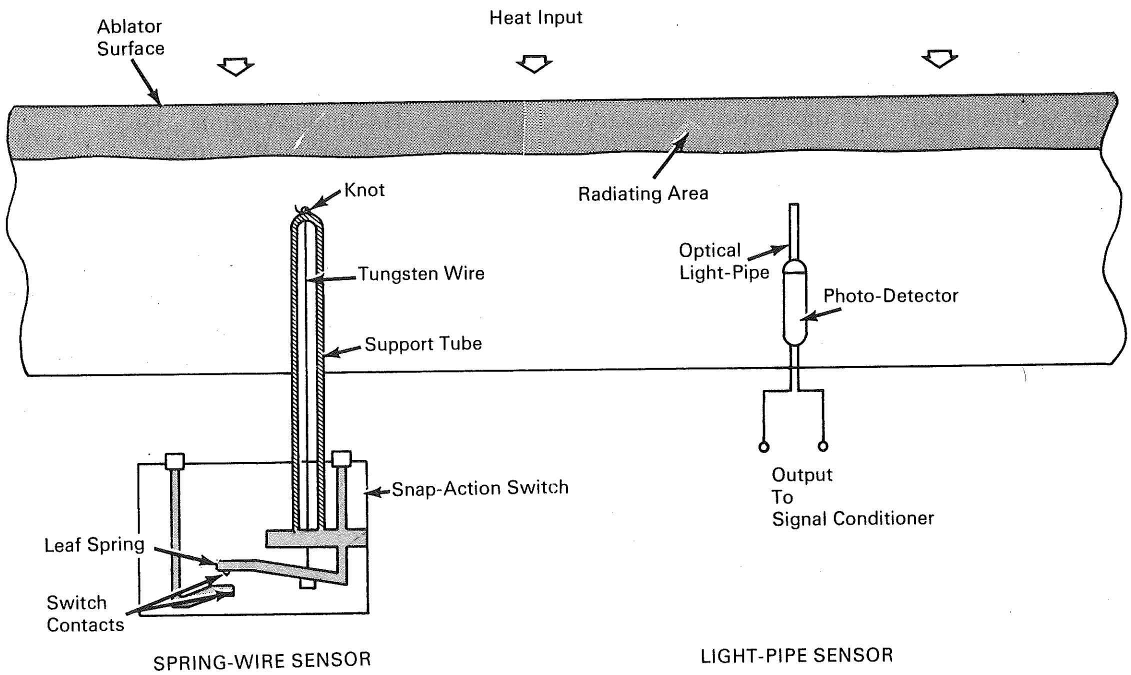
No patent action is contemplated by AEC or NASA.

Source: W. D. Loftus
of Westinghouse Astronuclear laboratory
under contract to
AEC–NASA Space Nuclear Propulsion Office
(NU-0089)

December 1966 Brief 66-10592

NASA TECH BRIEF

Sensors Measure Surface Ablation Rate of Reentry Vehicle Heat Shield



The problem:

The measurement during reentry of the surface erosion rate of the ablation material which provides heat protection for the spacecraft. To be effective, the technique used must meet the requirement that a minimum of foreign material be embedded in the heat shield to insure that the sensing device will not disturb the basic ablative properties of the material. Also, the instruments must be simple, highly reliable, and unaffected by the external reentry environment, particularly the ionized plasma surrounding the space vehicle.

The solution:

Placement of a number of simple event sensors at precise depths in the heat shield. Each sensor is activated when the ablator surface erodes to the location of a sensing point. Knowing the depth of each sensing point and the time of activation, ablator surface erosion rate can be determined.

How it's done:

The light-pipe sensor uses the visible radiation present at the surface of an ablating heat shield. An

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optical system consisting of a high melting point optical fiber and photodetector is embedded in the ablation material. As the ablation process advances, the heated area above the end of the optical fiber becomes incandescent and the radiated light is channeled through the fiber to the photodetector. As the ablation surface approaches the end of the fiber, the intensity of the light increases causing a proportional change in photodetector output. When the detector output reaches a predetermined level which has been experimentally selected to correlate ablator surface position with the end of the fiber, electronic switch closure circuitry is actuated.

The spring wire sensor consists of a metal tube attached to a snap-action switch. The tube is constructed of material which melts at or near the expected ablator surface temperature. A fine tungsten wire, fixed to the end of the tube, is passed through the tube and attached to the leaf spring of the switch to hold the spring in tension. The tubing is located in the ablator at the desired depth. As the material surface erodes to the location of the sensor, the very steep temperature gradient at and just beyond the ablator surface softens the tubing and releases the wire, allowing the switch to close.

Notes:

1. The light-pipe sensor in its present configuration is limited to applications in materials which are not transparent. Synthetic sapphire, .016" dia., is used to construct the optical fiber. The choice of tubing for the spring wire sensor depends on the ablator surface temperature. High melting point tubings such as tungsten–rhenium and molybdenum have been used with heat shields having high surface temperatures. For conditions where surface temperatures are lower, aluminum and stainless steel support tubes have been used successfully. The support tube diameter is .020".
2. These sensors have been used in several material evaluation flight experiments and a multitude of ground plasma-jet tests. Other tests have been conducted in rocket-exhaust facilities of the New York Atomic and Development Authority—Malta Test Station. Tests were conducted in a variety of ablators including phenolic–graphite, high and low density phenolic–nylon, teflon, silicon rubber based materials, and an epoxy novelac composite.
3. Additional information is contained in: (a) a paper presented to the 20th Annual ISA Conference and Exhibit, October 1965, "Development of Ablation Sensors for Advanced Reentry Vehicles," and (b) NASA TN D-3686 "Development of Sensors to Obtain In-Flight Ablation Measurements of Thermal Protection Materials."
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10592

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: J. M. Russel, III

(Langley-287)

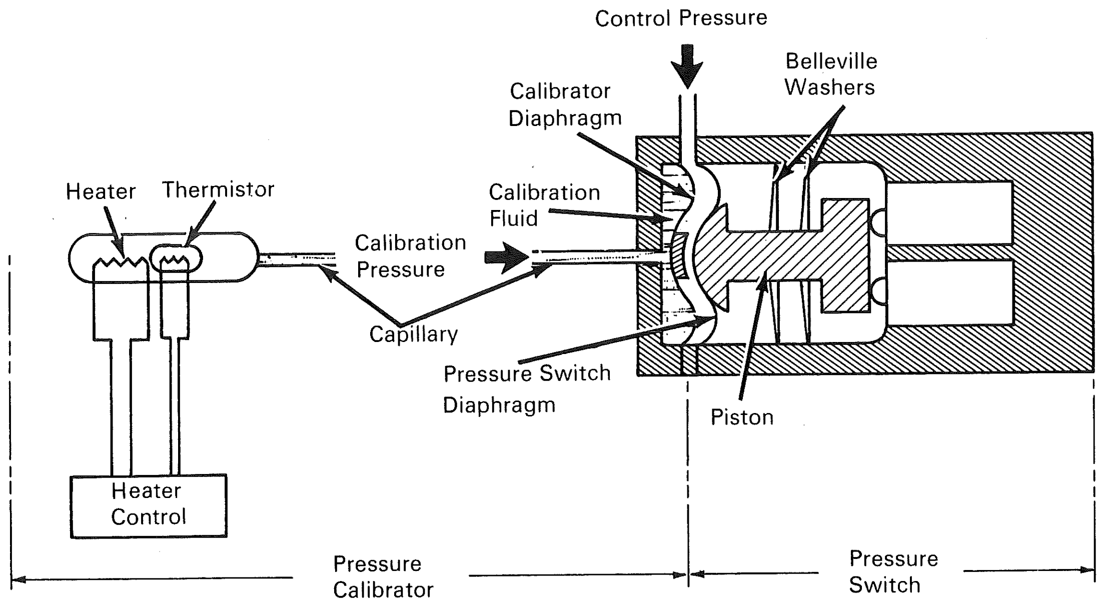
December 1966

Brief 66-10598

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Design Concept for Pressure Switch Calibrator



The problem:

In conventional pressure switches, fluid pressure acting on a summing diaphragm generates a force on a piston constrained by a pair of Belleville washers. As the pressure is increased, displacement of the piston may amount to several mils, while an additional displacement of several mils occurs abruptly during switching action (snap action of Belleville washers). In certain applications, pressure switches must operate within specifications under 150 g shock loads. Conventional pressure switches are not balanced for such loads, and therefore exhibit an acceleration sensitivity. To minimize this sensitivity, Belleville washers are designed to have a restraining force which is large compared to the unbalanced acceleration forces. Typically, a force of 150 pounds must be applied to the piston, in order to actuate the switch. Precise in-place calibration of such a switch therefore requires a method by which a known or measurable force of up to 150 pounds can be generated and applied to the switch diaphragm (summing member) in such a way that the magnitude of the force is unchanged by the displacement of the diaphragm.

The solution:

A calibrator and switch design employing a saturated liquid-to-vapor phase transition at constant pressure to produce a known force (on a diaphragm of given area) independent of displacement over a usable range.

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How it's done:

As shown in the sketch, one end of a conventional pressure switch is modified by the addition of a diaphragm enclosing an appropriate calibration liquid which communicates with a controlled source of heat by means of a capillary. For the calibrator diaphragm configuration sketched, the calibration liquid is assumed to be cold, so that it is fully contracted. In this condition, any measured or control pressure greater than the vapor pressure of the liquid would not allow a calibrating force on the switch diaphragm. The spacing between the diaphragms would be chosen to allow for expected displacement of the fluid (liquid plus vapor) in the operating environment.

To conduct a calibration, the control pressure would be reduced to atmospheric pressure (by valving) and the heater control system would be actuated. As the temperature of the fluid near the heater is increased, a point will be reached at which the vapor pressure exceeds the atmospheric pressure on the liquid (plus any loading pressure from the calibrator diaphragm). The resultant force (the product of vapor pressure and calibrator diaphragm area) will displace the calibrator diaphragm until it contacts the switch diaphragm. When switching pressure is reached, the displacement of the switch diaphragm would not affect the calibrating pressure, because it is essentially independent of the volume of the calibrating fluid. The fluid (vapor pressure vs temperature characteristics) and calibrator diaphragm area would be selected so that a calibrator unit of one design would be applicable to pressure switches used for a wide range of control pressures.

Notes:

1. A calibrator based on this concept would be most useful where the calibration could be carried out at a relatively slow rate so that saturated vapor conditions could be maintained in the region enclosing the heater and thermistor.
2. This device is in the conceptual stage only, and as of the date of publication of this Tech Brief, neither a model nor a prototype has been constructed.

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

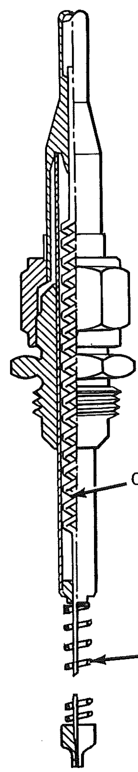
Source: M. G. Slingerland
of General Electric
under contract to
Headquarters, NASA
(Hq-36)

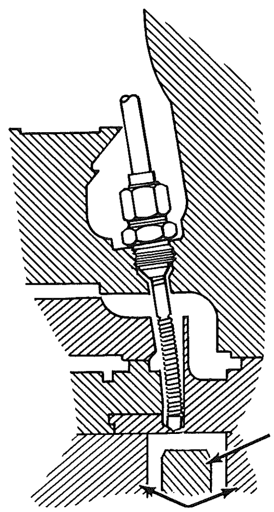
December 1966

Brief 66-10599

NASA TECH BRIEF

Pressure Probe Compensates for Dimensional Tolerance Variations





The problem:

Measuring the static pressure between the rotor stages on an axial flow fuel pump necessitated a specially designed probe to compensate for dimensional tolerance variations and access hole centerline offset in adjoining parts of the pump. The probe was required to compensate for length differences of approximately 0.25 inch and be capable of making a blind bend upon insertion and compensating for adverse tolerance stackup.

The solution:

A flexible, compressible spring loaded pressure probe.

How it's done:

The probe consists of a flexible, coiled impulse tube within a housing and loaded with a 30-pound spring to ensure positive seating at the probe tip.

(continued overleaf)

Notes:

1. This flexible static pressure probe would be useful in installations where a drilled static pressure tap or a rigid impulse tube cannot be used. The probe parameters must be specially determined for each installation, taking into account frequency response, effects of leakage past the probe tip on pressure measurements and test unit performance, and spring loading and mounting limitations.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10599

Patent status:

No patent action is contemplated by NASA.

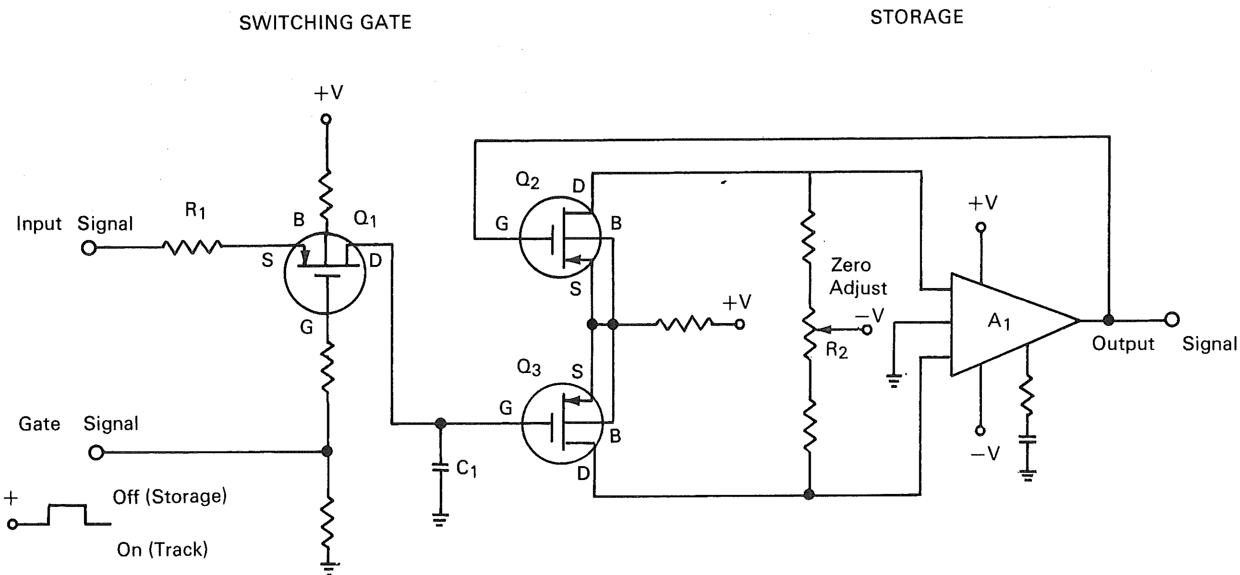
Source: R. A. Birner
of Aerojet General Corporation
(Lewis-302)

December 1966

Brief 66-10603

NASA TECH BRIEF

MOSFET Analog Memory Circuit Achieves Long Duration Signal Storage



The problem:

To provide a means of maintaining the signal voltage at the output of an analog signal amplifier when the input signal is interrupted or removed. For some automatic control and instrumentation applications, it is desirable to store and read out the last signal level input received prior to signal interruption so that no information is lost during the absence of input signal. In addition to a signal-storage mode, the unit must have a tracking mode of operation during which the output voltage of the unit must duplicate the input voltage.

The solution:

A memory circuit using MOSFET (Metal Oxide Semiconductor Field Effect Transistor) devices as voltage-controlled switches, triggered by an external voltage-sensing device. The circuit makes use of the zero offset switching capability and extremely high input impedance characteristics of MOSFET devices.

How it's done:

The memory unit is composed of three main parts: filter, R_1, C_1, to remove unwanted voltage variations or noise; an analog signal gate, Q_1, to switch the unit between its two modes of operation (tracking mode and storage mode); and a highly accurate unity gain storage device, Q_2, Q_3, R_2, A_1, to provide a duplicate of the input voltage at its output terminals.

When the input signal is applied, an external sensing device turns the input gate, Q_1, "on" and places the unit into its tracking mode of operation. The voltage on the capacitor, C_1, represents the desired signal data and is applied to the unity gain amplifier, consisting of

(continued overleaf)

a pair of MOSFET devices, Q_2, Q_3, and an integrated operational amplifier, A_1. Balance control, R_2, is used to cancel any amplifier offset voltage.

Upon loss of input signal, the input gate is switched "off" by an external voltage-sensing device, thus converting the unit from a tracking mode to a storage mode of operation. The latest signal level received prior to signal dropout is stored in capacitor C_1 and is maintained at the output terminals of the circuit. Leakage of charge from capacitor C_1 through the two MOSFET devices, Q_1, Q_3, is impeded by the extremely high input and gate-off impedances of the MOSFET devices. Since the time constants of the capacitor-MOSFET impedances are extremely high, the voltage on the capacitor decays very slowly and can be considered essentially constant during the relatively short signal-dropout periods. When the input signal returns, the circuit is switched back into its tracking mode of operation by the external voltage-sensing device.

Notes:

1. Selection of a capacitor of proper material has resulted in time constants in the order of 10^5 to 10^6 seconds, values much larger than the longest signal dropout time anticipated.
2. The choice of time constant at the memory input is determined by the following:
   a. Amount of smoothing required
   b. Amount of decay encountered during switching time of gates
   c. Expected time between signal dropouts
   d. Time derivative of input signal
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10603

Patent status:

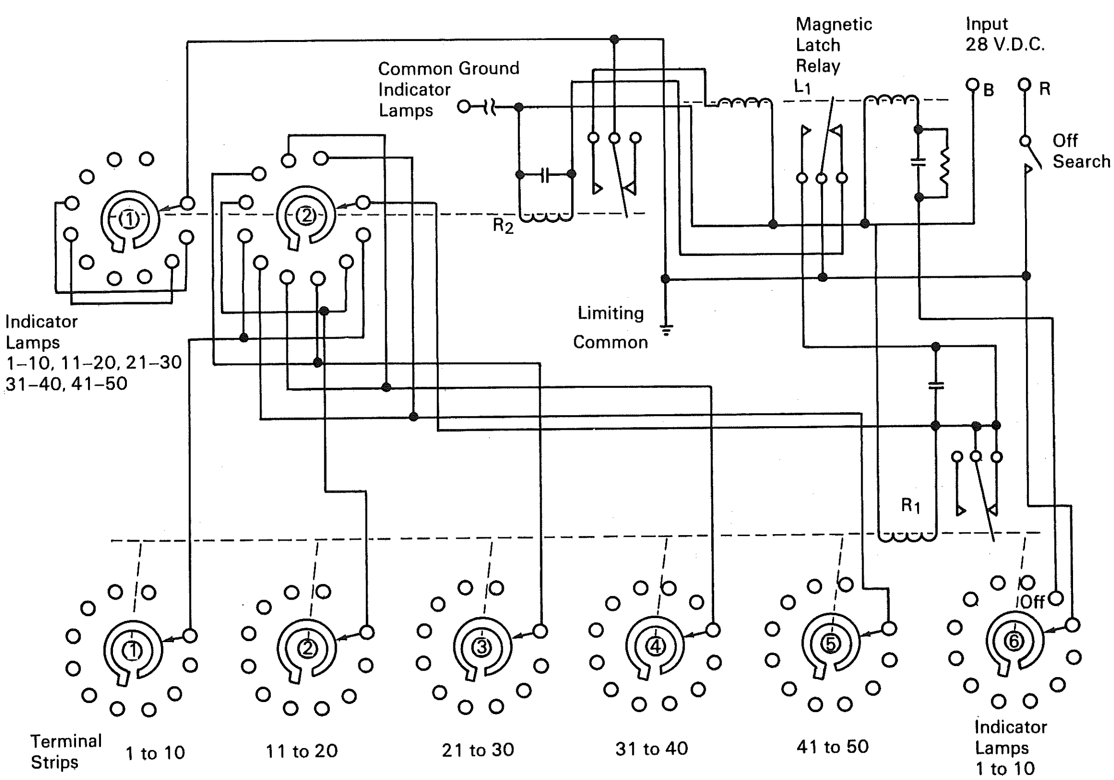
No patent action is contemplated by NASA.

Source: IBM, Federal Systems Division
under contract to
Marshall Space Flight Center
(M-FS-860)

December 1966 Brief 66-10605

NASA TECH BRIEF

Electrical Continuity Scanner Facilitates Identification of Wires for Soldering to Connectors



AUTOMATIC ELECTRIC RELAY, 6-DECK 11-POSITION

The problem:

In the development of electronic equipment, circuits may contain from 10 to 250 wires, each of which must be correctly identified. In assembling the circuit, often the first end of each conductor, or wire, has been attached to a known "primary" terminal or pin, the wires are bundled and routed in the desired configuration, and spot tied or laced to retain the desired appearance through most of the routing. The alternate "secondary" conductor end must then be identified with its "primary" to determine its proper end terminal point. For production runs, each wire is usually

(continued overleaf)

stamped with a number or otherwise labelled to facilitate identification. For experimental work continuity is usually checked with an ohmmeter, "buzz-box," or other means of indication of continuity between two points. This method is slow, tedious, and expensive.

The solution:

A electrical continuity scanner that can scan 50 points in 2 seconds, automatically searching for continuity.

How it's done:

One known point is electrically connected to the common post of the electrical continuity scanner with a temporary jumper wire. Actuation of the switch to the search position will cause rotary relays to step, or search, until a circuit having electrical continuity is reached, or the search switch is released. This automatic stepping is accomplished through use of contacts provided on the automatic electric relay (R1) to make it free running when desired. After 10 positions (10 wires) have been scanned, a second automatic electric relay (R2) (not shown) is actuated 1 position by latching relay (L1) to transfer the circuitry to the next 10 circuits. In this manner 5 decks with 10 positions may be used to accomplish scanning of 50 circuits in a fully automatic or free running manner.

When continuity is attained, a current of approximately 0.3 ampere at 28 volts dc will keep the relay held in, preventing further search, until observation of the indicator lamps indicates the number of the post providing continuity. The search switch may then be released and the known end point noted, with the post number providing continuity. The jumper wire is moved to the next known point and the search procedure is repeated until all wires in the bundle have been correlated with their respective known ends.

Notes:

1. Modifications can be made to the basic plan to provide circuitry for scanning up to 250 wires. Digital readout of numbered positions can be readily provided.
2. The wires to be tested can be used without stripping or damage to the insulation if special test leads are constructed by soldering steel phonograph needles to mini-gator clips.
3. One electrical continuity scanner has been constructed with the relays and circuitry inside a chassis box 10 inches by 6 inches by 3 1/2 inches, with terminal strips for 50 circuits, a common post, and 2 power input posts on top. Input power to drive this scanner was less than 1 ampere at 28 volts dc.
4. The scanner can also be used for the rapid fabrication of multiwire electrical cables by minimizing termination errors prevalent with prior methods of wire identification.
5. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10605

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Ralph A. Diclemente
and Howard C. Boulton
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-626)

December 1966

Brief 66-10606

NASA TECH BRIEF

A Radiometer–Pyrometer

A radiometer–pyrometer was developed for the measurement of the spectral absorption, emission, and temperature of gases. The major problems involved in spectroradiometric measurements and the methods of overcoming them in this instrument are as follows:

(1) Nonuniform spectral sensitivity. The sensitivity of most radiation detectors varies with time, temperature, fatigue, and other factors, so that the error of absolute flux measurements is generally greater than 1 percent. By providing an internal reference lamp that has greater long term stability than the detector and alternately measuring the reference and the sample radiation with the same detector, accuracy approaching the reference can be obtained. This principle has long been used in optical pyrometers, and successfully applied to automatic pyrometers, radiometers, and other commercial instruments.

(2) Nonlinearity. When the internal reference lamp is operated at a fixed temperature, a ratio of the sample radiation to the reference can be obtained. Large ratios, however, require either a detector with linear response or a calibrated nonlinear detector. Also, large ratios may be subject to error in the smaller flux measurement caused by the addition of stray radiation from the larger flux. By attenuating the internal reference source with an aperture, an approximate match to the sample radiation within a 10:1 ratio can be made. The detector linearity requirement is thereby lessened, and the linearity errors are minimized. This method is used in the present instrument, with 4 beam attenuators giving a reference-lamp-flux range of 10^6. In addition, the reference-lamp current is continuously variable and gives an additional flux range of 10^2.

(3) Poor absolute accuracy. By using the internal reference lamp as a transfer device, the ratio of intensity of an external sample source to intensity of an external standard source becomes the actual measurement. Available external standard spectral sources are commercial blackbody cavities at 1000°C and a calibrated tungsten ribbon lamp.

(4) Wide range of intensities. A limitation of the thermal radiator as an external standard source is the wide variation of intensity with wavelength in accordance with the Planck spectral distribution. In the ultraviolet, the intensity of a 2860°K blackbody changes greatly for even a slight change of wavelength so that, for example, from a peak intensity at 1 micron it is reduced by a factor of 10^5 at 0.2 micron. Thus, over a wide range of wavelengths, an incandescent lamp is far from an ideal spectrally independent source. This fact tends to complicate its use as a reference by which a measurement is divided. The complication is minimized in applications such as automatic pyrometers, where the utilized wavelength range of the lamp is limited or fixed. The wide range of intensity level is covered in this instrument with detector apertures giving an attenuation range of 10^3 and amplifier gain that is variable over a range of 10^3.

(5) Wide range of wavelengths. No one detector is best at all wavelengths. The detection improves as the range of detector response is confined to the short wavelengths, where a photon has greater energy and ambient radiation is small. Thus, the photoemissive detector limited to the ultraviolet and visible spectrum is superior to a photoconductor, which responds to wavelengths extending from the ultraviolet through the near infrared. Such a photoconductor, in turn, is superior to the thermal detector, which responds to

(continued overleaf)

the far infrared as well. A choice of three detectors is provided in this instrument to obtain the best detection at any wavelength.

Note:

Details concerning the design and operation of this instrument are given in NASA TN D-2405, "Radiometer-Pyrometer for Analysis of Gaseous Combustion Processes", by Donald R. Buchele, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Inquiries may also be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B66-10606

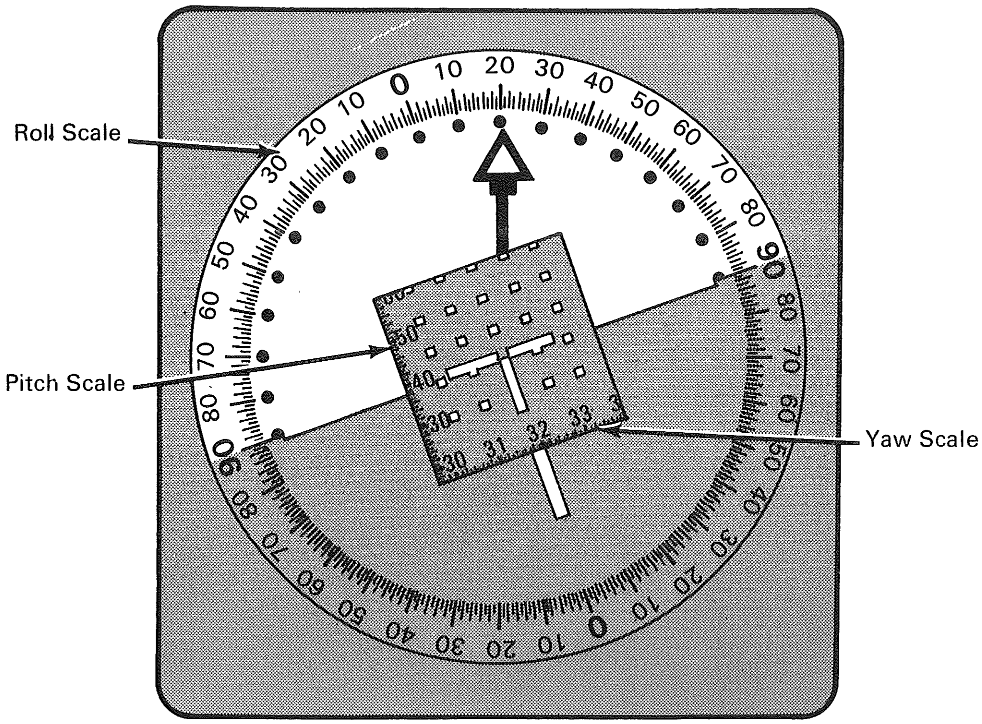
Patent status:

No patent action is contemplated by NASA.

Source: (Lewis-284)

NASA TECH BRIEF

Developmental Instrument Supplies Accurate Attitude and Attitude-Rate Data



The problem:

To provide accuracy of readout of both attitude and attitude-rate information in an easily interpreted, uncluttered arrangement where blind navigation of a moving body is involved. The "All Attitude Ball" (now 24 years old) that gives a spherical presentation, suffers a bit from the fact that its longitudinal length (yaw) scale indication declines with changes with latitude (pitch).

The solution:

A three orthogonal-plane projection in which the longitudinal length is constant, and therefore independent of the pitch and roll attitudes of the moving body. The configuration is quite similar to the outer framework of a child's spinning gyroscope top.

How it's done:

Three tapes, orthogonally mounted, are installed on drive members behind a back-lighted display plate.

(continued overleaf)

The tapes are divided into scale increments that indicate the degrees of roll, pitch, and yaw, respectively, being experienced by the moving body. This reference attitude indicator is a repeater type of display that uses transducers as rate gyros to operate synchronous motors to drive the scaled tapes in response to changes in attitude of the moving body.

Notes:

1. Slewing speed in all three axes is 90° per second. Static accuracies of indication in all three axes are better than one arc degree, indicated. Sensitivity to rates of change is in the order of 0.01 degree of arc per second.
2. The pitch and yaw servos have a velocity constant of 97, while that of the roll servo is 55. Servo bandwidth is about 6 cps for pitch and yaw, and 5 cps for roll.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Headquarters
   National Aeronautics and Space Administration
   Washington, D.C. 20546
   Reference: B66-10607

Patent status:

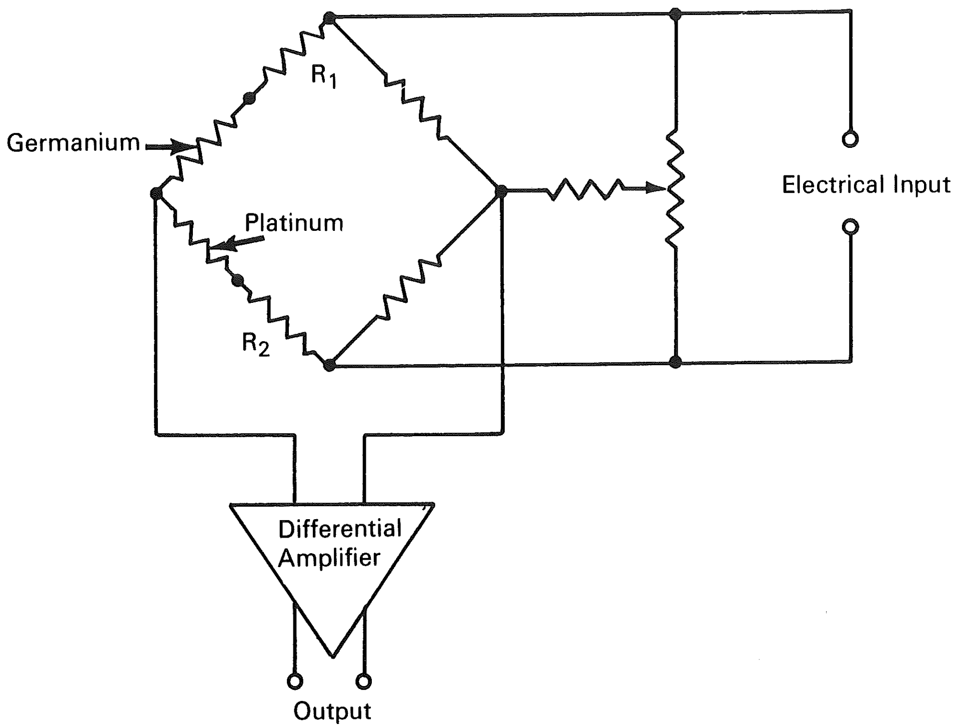
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Bolt, Beranek, and Newman, Inc.
under contract to NASA
(HQ-57)

December 1966 Brief 66-10612

NASA TECH BRIEF

Resistance Thermometer Has Linear Resistance-Temperature Coefficient at Low Temperatures



The problem:

To devise a resistance thermometer that will have a linear temperature-resistance coefficient over a range from approximately –140°C to approximately –253°C. At the lower end of this range, the resistance-temperature curve of the standard platinum resistance thermometer is nonlinear.

The solution:

A resistance thermometer incorporating a germanium resistance element (which has a negative temperature coefficient) with a platinum resistance element in a Wheatstone bridge circuit.

How it's done:

The platinum and germanium resistors are connected as adjacent legs in the Wheatstone bridge. Resistors R_1 and R_2 may be placed in series with the platinum and germanium resistors for balancing purposes. As the temperature varies, the resistances of the two legs vary in opposite directions so that the nonlinearities of their respective resistance vs temperature curves effectively cancel. As a consequence, an essentially linear output (which is a measure of the temperature) is obtained from the differential amplifier over the indicated temperature range.

(continued overleaf)

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Western Support Office
150 Pico Boulevard
Santa Monica, California 90406
Reference: B66-10612

Patent status:

No patent action is contemplated by NASA.

Source: W. Kuzyk
of General Dynamics
under contract to
Western Support Office
(WOO-190)

NASA TECH BRIEF

Study of Theory and Application of Long Duration Heat Flux Transducers

The extreme thermal environments encountered in the base region and other areas of large rocket-powered vehicles have created special design problems which require a knowledge of the intensity of the heat transfer to be expected. To acquire this knowledge, heat transfer measurements have been made during scale model tests and flight tests of these vehicles.

During the early scale model "hot flow" testing of Saturn I the lack of existing knowledge and experience in heat flux measurements resulted in the accumulation of base heating data which was difficult, if not impossible, to analyze. To help overcome this lack of knowledge and experience, a study program was initiated and resulted in the development of instrumentation employing the latest state-of-the-art concepts for heat flux measurements.

An outline of the theory and application of the various types of heat flux transducers that are used to measure the "long duration" variety, that is, they are used in tests of more than a second's duration, is contained in a paper, "Theory and Application of Long Duration Heat Flux Transducers," by S. James Robertson and John P. Heaman.

The paper describes various devices and techniques for the measurement of heat flux. It discusses the principles of operation of the slug type sensor and the steady-state sensor and certain design parameters for these sensors. Also discussed are special considerations for the application of both radiation and convection measuring devices, and the various types of heat flux simulators used in calibrating heat flux transducers.

Note:

The paper described above is available from:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10614

Patent status:

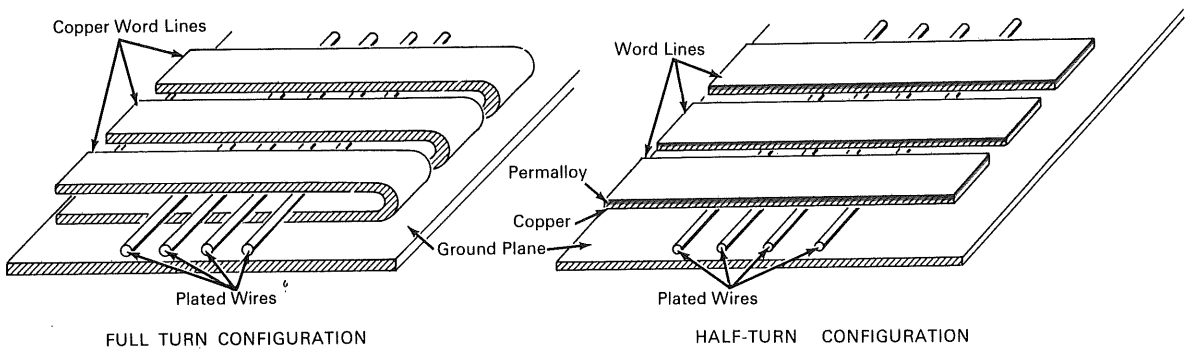
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: S. James Robertson
of Heat Technology Laboratory, Inc.
and John P. Heaman
of Marshall Space Flight Center
(M-FS-1265)

Category 01

NASA TECH BRIEF

Improved Memory Word Line Configuration Allows High Storage Density



The problem:

To design a plated wire memory word drive line configuration which allows high storage density, good plated wire transmission characteristics, and a simplified memory plane configuration. Prior art used a plain copper full-turn word line to obtain word field uniformity. With the plain copper word line the word field spread to the extent that the desired high storage density could not be obtained. Also, with this configuration the connections have to be made to both ends of the word line to obtain efficient selection of the word lines. With both ends of the word line available at the same side of the plane, the connections are complicated, particularly since the two ends are in different layers of the plane construction. The full turn construction does not allow good plated wire transmission characteristics because of the presence of the copper word line between the plated wire and the ground line return path.

The solution:

A half-turn word drive line with a magnetic keeper. The ground plane provides the return path for both the word current and the plated wire transmission line.

How it's done:

The half-turn word line structure is made by copper plating a thin magnetic sheet which is cemented to a supporting dielectric. This composite is then photoetched leaving the desired word line pattern. The copper and the magnetic material are etched away at the same time. High storage density is achieved by having magnetic strips slightly wider than the word lines on top of the word lines. These strips provide a low reluctance path for the word field and inhibit it from spreading.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10617

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: UNIVAC
under contract to
Goddard Space Flight Center
(GSFC-559)

December 1966

Brief 66-10619

NASA TECH BRIEF

Computer Program Simplifies Transient and Steady-State Temperature Prediction for Complex Body Shapes

The problem:

To devise a fast, efficient method of predicting transient and steady-state temperature distributions throughout an object of complex shape when heat sources are applied to specified points on the object. The method of obtaining temperature distributions of the object under observation must be capable of considering any or all of the three modes of heat transfer: conduction, convection, and radiation. Analyses of bodies of complicated shapes usually require complex and time-consuming manual computations.

The solution:

A computer program which utilizes an electrothermal model to simulate the conductance, heat capacity, and temperature potential of the object under study. The program is capable of evaluating all three modes of heat transfer and will calculate either the transient or steady-state temperature distributions.

How it's done:

The program solves heat transfer problems by establishing analogies between the physical phenomena of thermal heat flow and electrical current flow, and between temperature and voltage potential.

The object under consideration is simulated by a large number of nodal points, each representing a small portion of the object. These nodes form a network which provides an accurate physical definition of the object. The computer then accepts the following input information:

1. The thermal heat capacity of each nodal point.
2. The conductance values of the three possible heat transfer (current) paths between a node and its neighboring nodes.
3. The network nodes to which the initial temperatures (voltages) are applied.

The program then executes:

1. For each node, a value of capacitance, which is an electrical statement of the heat capacity of the object at that particular nodal point.
2. A resistance–capacitance time constant, which indicates the instantaneous value of the current present at a given node.

A printout of the solutions to the transient or steady-state potentials at the network nodes may be requested at any time during the program. Since each nodal point corresponds to one point on the object under observation, the network current values obtained from the printout are directly proportional to the heat flow existing in the object. Nodal voltage potentials obtained from the printout are proportional to the temperature distributions throughout the object.

Notes:

1. The program has been written in the FORTRAN IV language for use on the IBM 7094 computer.
2. The program can be used to solve problems described by a form of Laplace's equation, or the continuity equation. Other possible applications include fluid flow studies, traffic flow problems, and structural analysis.
3. Inquiries concerning this invention may be directed to: COSMIC
   Computer Center
   University of Georgia
   Athens, Georgia 30601
   Reference: B66-10619

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

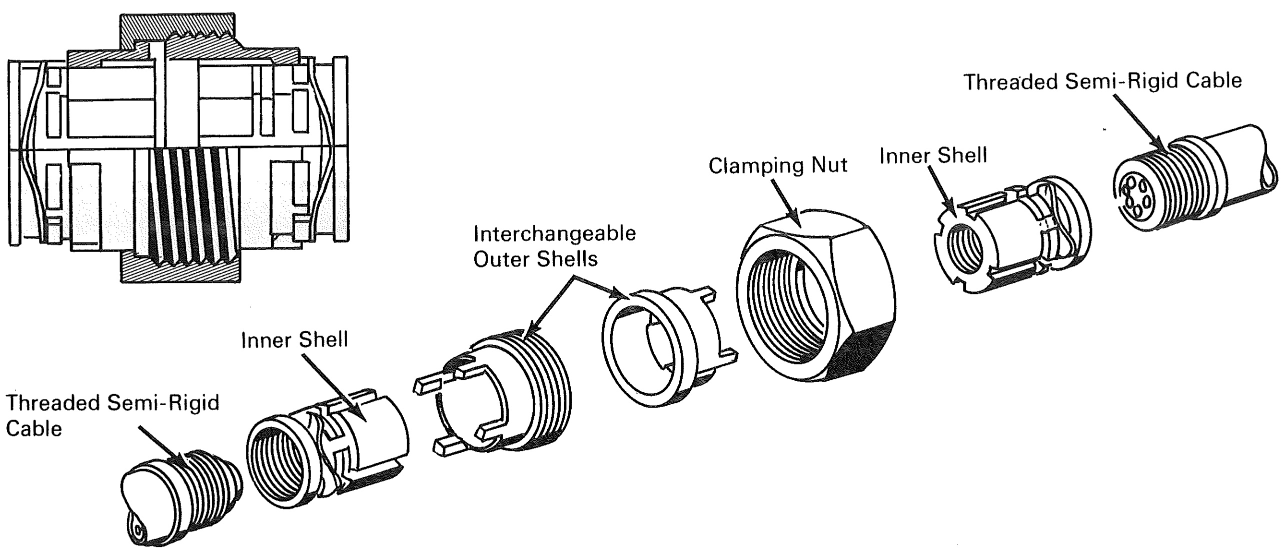
Source: K. N. Giebler
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-989)

December 1966

Brief 66-10621

NASA TECH BRIEF

Connector Acts as Quick Coupling in Coaxial Cable Applications



The problem:

Present coaxial cable connectors employ a skive ring to couple the connector body to the cable and this ring frequently galls and deforms the cable, adversely affecting the connection electrical characteristics. Also, present connectors require a great deal of time and effort in accomplishing a good coupling plus a relatively high degree of skill on the part of the technician.

The solution:

A quick-coupling connector whose inner shells are threaded to the cable ends and whose outer shells have tracks that register in channels machined in the inner shells and are then rotated 45° to effect a locking of the coupling. A clamping nut holds the outer shells together and prevents their unlocking.

How it's done:

Each connector inner shell has four L-shaped channels machined at 90° intervals, and each outer shell has four tracks also machined at 90° intervals. The inner shells are first threaded onto the two cable ends to be joined; the outer shell tracks are then guided through the inner shell channels until they bottom, at which time the outer shells are rotated 45° and locked to the inner shells. The clamping nut is brought into engagement with the outer shells and forces the raised flange of the unthreaded shell against the end of the threaded shell as it engages that shell's threads.

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Notes:

1. An air transition that is formed by the connector interface serves as an impedance matching device to yield a very low voltage standing wave ratio of less than 1.02 over the S-band frequency range with an insertion loss of less than 0.01 db.
2. This connector faithfully reproduces excellent electrical characteristics no matter how frequently assembled and disassembled.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10621

Patent status:

No patent action is contemplated by NASA.

Source: Albert G. Brejcha, Jr.
(JPL-803)

December 1966

Brief 66-10622

NASA TECH BRIEF

Point-Source Detection System Rejects Spatially Extended Radiation Sources

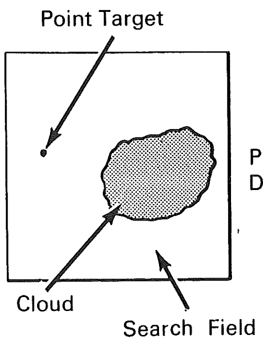

FIGURE 1

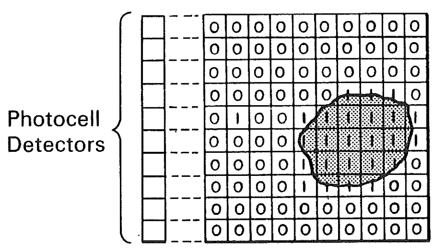

FIGURE 2

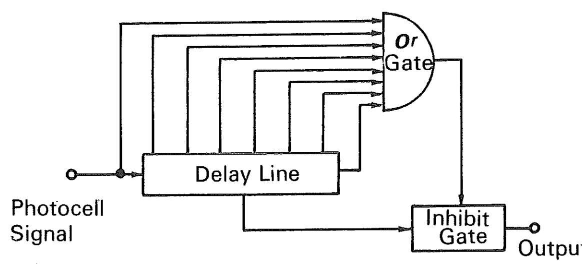

FIGURE 3

The problem:

To devise a reliable method for discriminating a distant (point source) target from false (spatially extended) targets in the field of view of an infrared detection system or tracking device. Various spatial discrimination methods (spatial filtration, pulse-length discrimination, area cancellation, and analog space correlation) that have been used to distinguish characteristic differences between the signals from a point target and those from larger-area targets require generally complex circuitry and are not entirely suitable for tracking a reentering space vehicle.

The solution:

A system employing digital space correlation to suppress false target signals in a point-target tracking device.

How it's done:

The search field (Figure 1), containing the point target to be tracked and a cloud representing an extended-area false target, is divided into a matrix of rows and columns of elemental fields of view. As shown in Figure 2, digital values are assigned to the matrix elements. That is, the elements containing no target radiation are designated by zeroes, and the elements in which target radiation appears are designated by ones. In accordance with the method described below, adjacent elements (such as those corresponding to the cloud) having targets are eliminated. Only the individual element corresponding to the point target is accepted.

Photocells mounted in a column are moved across the field matrix to scan the elements sequentially. When target radiation of sufficient intensity (above a threshold value) impinges on a photocell that is sampling a particular matrix element, the photocell will emit a signal pulse. If no radiation, or only a very low amount of radiation impinges on the photocell, the cell's output will be rejected. The pulses are fed to an *or* gate and to a delay line having seven

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outputs that are also applied to the *or* gate (Figure 3). The output from the *or* gate is applied to the inhibit input of an inhibit gate, and an eighth signal output from the delay line is coupled to the signal input of the inhibit gate. When there is a signal correspondence between one input to the *or* gate and the signal output from the delay line to the inhibit gate, no signal will pass through the inhibit gate. This correspondence occurs only for signals from photocells that sample an array of adjacent matrix elements intercepting an extended area target.

Note:

Inquiries concerning this system and modifications that will resolve certain ambiguous cases may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10622

Patent status:

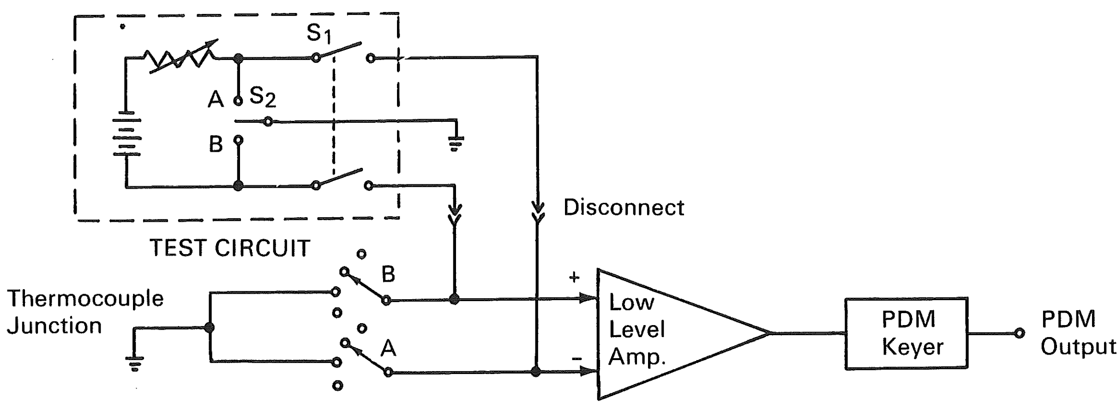
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. F. Maxwell, Jr.
of Westinghouse Electric Corporation
under contract to
Goddard Space Flight Center
(GSFC-486)

December 1966 Brief 66-10623

NASA TECH BRIEF

Thermocouples Electrically Checked While Connected to Data System



The problem:

To monitor the electrical continuity and resistance of multiple thermocouple installations without disconnecting them from a data system.

The solution:

A constant current source is connected across the input of the millivolt measuring system. As each thermocouple is sampled, the system output voltage is a direct function of the thermocouple loop resistance.

How it's done:

A constant current source consisting of a battery and adjustable resistor is connected across the PDM (Pulse Duration Modulation) output of the commutator in proper polarity. As each thermocouple loop is sampled by the commutator, the voltage across the loop is proportional to its resistance and the voltage readout signal is a measure of this resistance. The current source is adjusted so the voltage across a known resistance, greater than the resistances to be measured, equals the full scale range of the data system. A readout is first taken with S_1 open to confirm the absence of tare voltages. A readout with S_1 closed then directly reflects the thermocouple resistances, with the readout for an open circuit depending on system limiting characteristics. Placing S_2 in the A or B positions provides a measurement of the resistance of each leg of the thermocuple circuit if the junction is grounded and the measuring system has differential inputs as indicated.

Notes:

1. This technique was evolved and used for periodic monitoring of the condition of a large number of very small gage thermocouple leads during the assembly and preflight testing of the Project Fire reentry packages.
2. Typical resistances measured ranged from 20 to 400 ohms. The test circuit was set for 0.1 milliampere so that the 50 millivolt range of the system represented 500 ohms full scale.

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3. While a PDM system is shown, the technique should be equally usable with PAM (Pulse Amplitude Modulation) or other modulation systems.
4. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10623

Patent status:

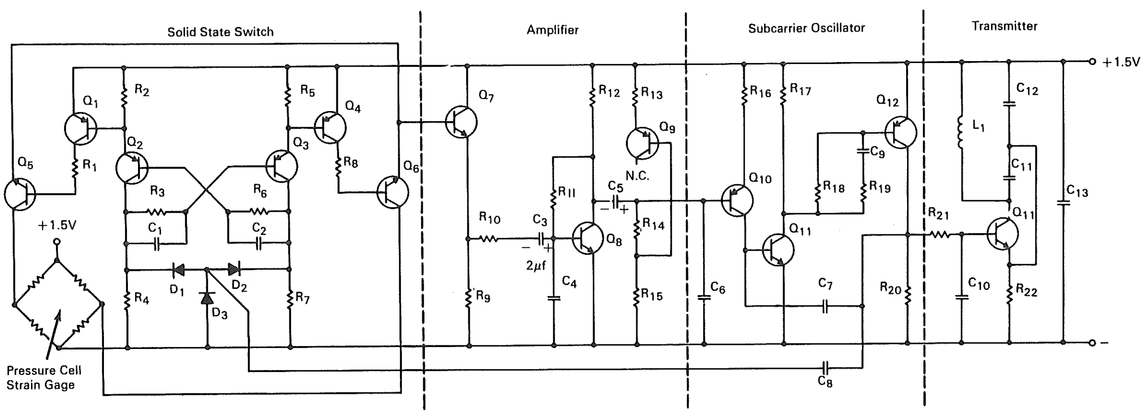
No patent action is contemplated by NASA.

Source: Republic Aviation Corporation
under contract to
Langley Research Center
(Langley-182)

December 1966 Brief 66-10624

NASA TECH BRIEF

Miniature Telemetry System Accurately Measures Pressure



The problem:

To design a telemetry system to accurately measure pressure with a small implantable pressure cell and transmitter. The system must operate with low power consumption.

The solution:

A miniature, low power, telemetry system that can be used with any of a number of commercially available strain gage pressure transducers. A small, solid state, strain gage pressure cell, designed for implanted physiological applications, is used with the new circuitry to provide a complete, implantable pressure transducing system.

How it's done:

The electronic circuit uses a pulse code modulation similar to ones previously used for temperature and biopotential monitoring. The subcarrier modulation technique allows accurate transmission of the low output level of the pressure cell from an implanted location to a remote radio receiver. The small strain gage signal (approx. 15 mv for 250 mm of Hg) is chopped by means of a solid-state switch (Q_1, Q_2, Q_3, Q_4, Q_5, Q_6) and amplified by an ac amplifier Q_7 and Q_8 (gain approximately 5). After amplification the signal controls the period of an astable multivibrator (Q_9, Q_{10}, Q_{11}, Q_{12}) operating at approximately 1 kHz. The pulse derived from the astable multivibrator is applied through C_8 to obtain synchronous operation of the solid-state switch, thereby causing the period of the multivibrator to be controlled alternately by the voltage derived from Q_5 and Q_6. The difference between successive periods then is proportional to the bridge unbalance signal and hence the pressure. The interval between pulses at bridge balance would be identical, but in order to avoid ambiguity the bridge is initially unbalanced in such a manner that one period remains smaller than the other over the

(continued overleaf)

entire operating pressure range. A typical modulation of ±20 percent of the mean period is obtained for a pressure change of 250 mm of Hg.

The short pulse developed by the astable multivibrator (approx. 20 microsecond long) is used to turn on the rf oscillator, Q_{13}. L_1 is used both as a tank circuit inductor and as a transmitting antenna. Since the information is derived from the time period between rf pulses, amplitude and frequency changes in the rf link do not affect the accuracy. After the pulses are received on a commercial FM receiver (88–108 MHz) a suitable demodulator is used to obtain an analog signal.

The telemetry system is shown with a protective coating of elasticized silicone rubber applied. In this condition, the system is ready for implantation.

Notes:

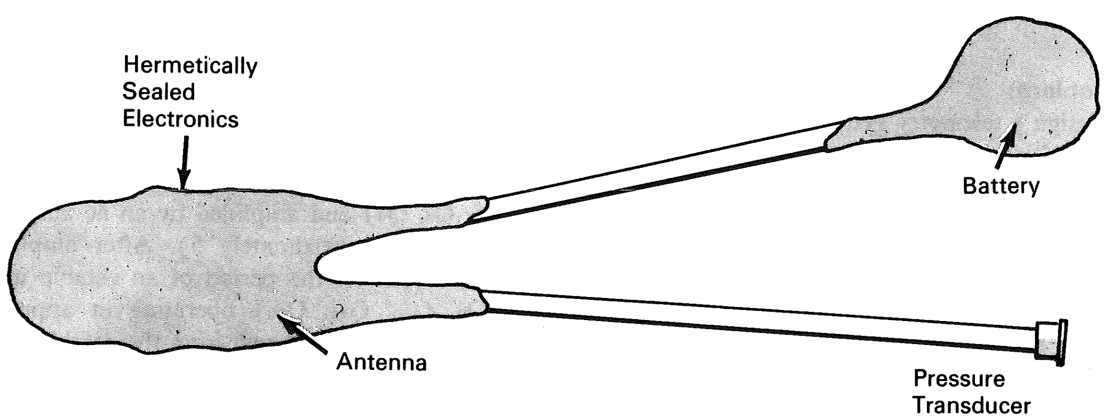
1. The system has been used to date only with pressure transducers, but the circuit is equally applicable to any measurement using a strain gage sensor. The pressure transducer is commercially available.
2. The transducer used is 6.5 mm in diameter and 1 mm thick. The lead-in wires terminate on the back of the transducer in a package that is 3.5 mm in diameter by 4.5 mm long.
3. The compensated temperature range of the transducer is from 77°F to 113°F. The telemetering electronics are suitable for temperatures to 150°F.
4. The battery lifetime of 500 hours is associated with a transmission distance of 3 to 5 feet. Increased transmission distance will be accompanied by increased power consumption with a reduced battery life. It is estimated that the battery life would be reduced to 125 hours for a transmission distance of about 100 feet.
5. Similar applications are described in Tech Brief 64-10171 for biopotential monitoring and Tech Brief 66-10057 for temperature monitoring.
6. Inquiries concerning this invention may be directed to:

    Technology Utilization Officer
    Ames Research Center
    Moffett Field, California 94035
    Reference: B66-10624

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: T. B. Fryer
(ARC-74)



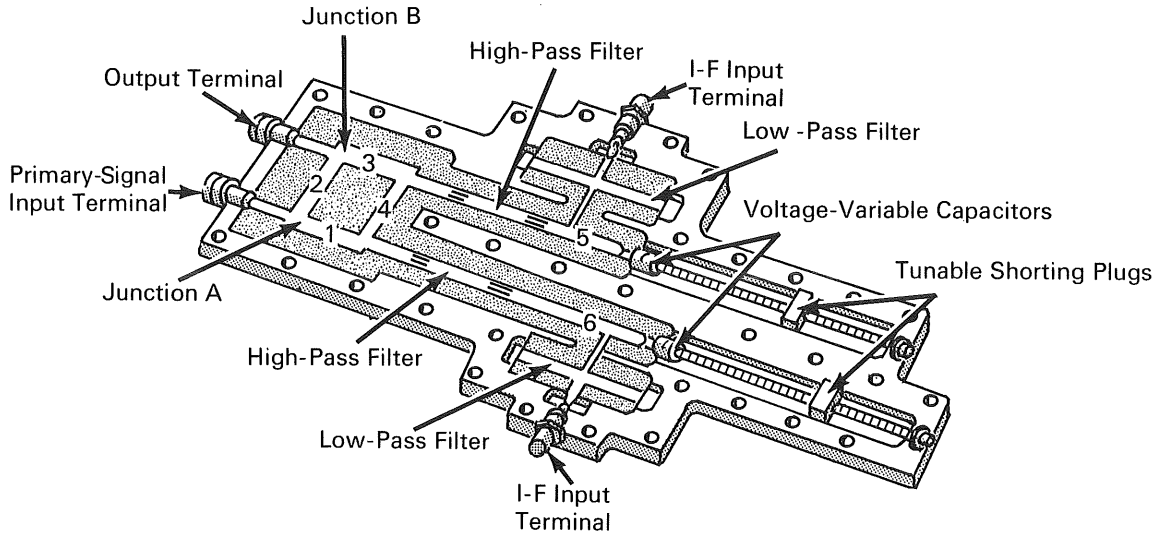
Miniature Telemetry System
Ready for Implantation

December 1966 Brief 66-10625

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Compact Microwave Mixer Has High Conversion Efficiency



The problem:

To design a compact, lightweight microwave mixer that will have a relatively high conversion efficiency and power output.

The solution:

A mixer employing a pair of back-to-back voltage-variable capacitors in a stripline network.

How it's done:

The mixer includes a branchline hybrid composed of branches 1, 2, 3, and 4; a pair of parallel stripline circuits 5 and 6, which include a high-pass filter in each stripline; a pair of voltage-variable capacitors, each connected in a back-to-back relationship at one end of the parallel striplines; and low-pass filters connected by stripline to the parallel striplines.

In operation, a primary frequency signal, applied to the input terminal, passes to branch 1 of the branchline hybrid. The hybrid splits the input signal, providing 2 signals which are 90 degrees out of phase. These out-of-phase signals are applied to the parallel stripline circuits (5 and 6). One of the parallel striplines (for example stripline 6) is a quarter wavelength longer than the other so that the signals are in phase at the ends of the striplines. Intermediate-frequency signals are applied through the low-pass filters to the voltage-variable capacitors at the ends of the parallel striplines (5 and 6). As a result of the heterodyne effect produced by the voltage-variable capacitors, the signals are reflected back down the parallel striplines. These signals include the high and low sidebands of the primary input signal. The reflected sidebands are passed by the high-pass filters, but rejected by the low-pass filters, thereby reaching the branchline hybrid (1, 2, 3, 4). Because of differences in electrical paths and

(continued overleaf)

phases, the sidebands are cancelled at junction A. However, the sidebands are reinforced at junction B, from where they pass to the output terminal. The two tunable shorting plugs may be varied over a selected frequency range to optimize the output level of the voltage-variable capacitors.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10625

Patent status:

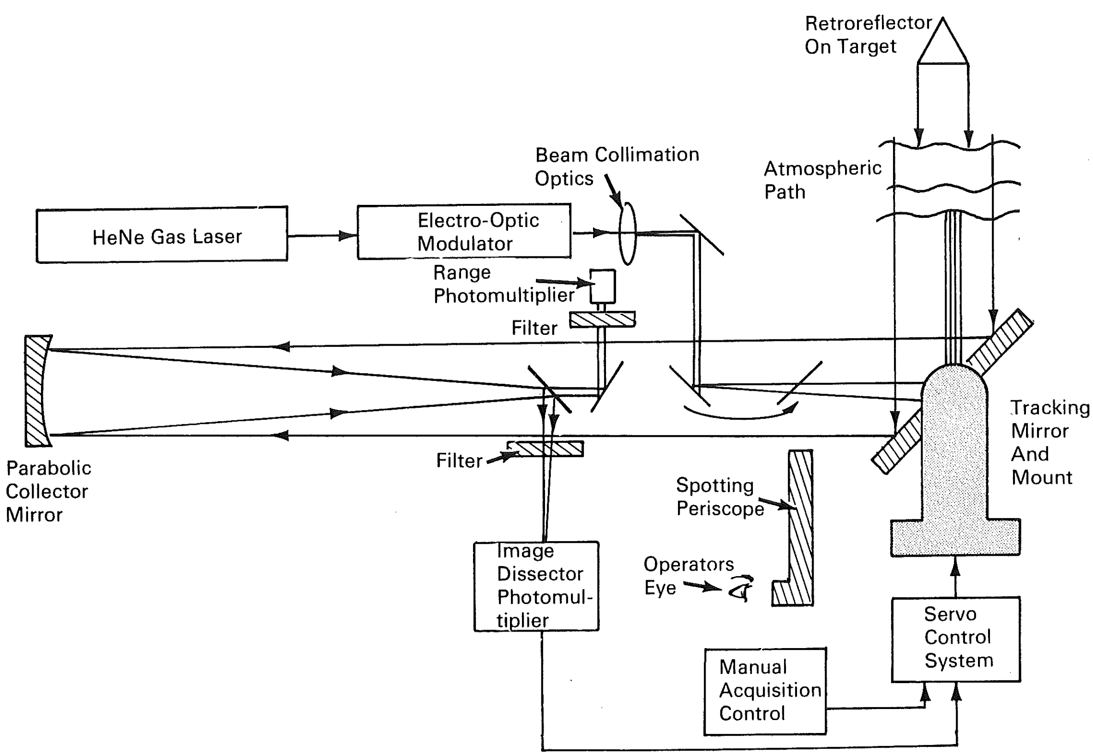
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: N. J. Penque and H. A. Rosen
of Hughes Aircraft Company,
under contract to
Goddard Space Flight Center
(GSFC-197)

December 1966 Brief 66-10629

NASA TECH BRIEF

Precision CW Laser Automatic Tracking System Investigated



A precision laser tracker has been constructed and tested which is capable of tracking a low acceleration target to an accuracy of about 20 microradians rms. In tracking high acceleration targets the error is directly proportional to the angular acceleration. For an angular acceleration of 0.6 radian/second^2 the measured tracking error was about 0.1 milliradian.

The basic components in this tracker, similar in configuration to a heliostat, are a laser and an image dissector, mounted on a stationary frame, and a servo controlled tracking mirror. The daytime sensitivity of this system is approximately 3×10^{-10} watts/meter^2; the ultimate nighttime sensitivity is approximately 3×10^{-14} watts/meter^2.

Experimental tests were performed to evaluate both dynamic characteristics of this system and the system sensitivity. Dynamic performance of the system was obtained using a small rocket covered with retroreflective material launched at an acceleration of about 13 g at a point 670 feet from the tracker. The daytime sensitivity of the system was checked using an efficient retroreflector mounted on a light aircraft.

(continued overleaf)

This aircraft was tracked out to a maximum range of 15 km which checked the daytime sensitivity of the system measured by other means. The system has also been used to passively track stars and the Echo I satellite. The system also passively tracked a +7.5 magnitude star, and the signal-to-noise ratio in this experiment indicates that it should be possible to track a +12.5 magnitude star.

The tracking accuracy against low acceleration targets is comparable to the accuracy of a star tracker. However, the laser tracker has the added capability of measuring range to the target. The accuracy exceeds that which can be provided by a high performance radar.

Interest in high precision tracking results from the instrumentation tracking requirements that arise at the missile ranges and other test stations. The advantage of optical tracking over radar tracking is that it is not affected by undesired reflections from surrounding objects, and the accuracy is somewhat less affected by variations in the index of refraction of the atmosphere. Laser tracking, as contrasted to passive optical tracking, has the advantage of discriminating against other optical sources and also has the capability of simultaneously measuring range. High precision tracking is also a necessary part of long-range optical communications which can be efficiently accomplished only by using very narrow beams.

Note:

Additional details are contained in the report: "Precision CW Laser Automatic Tracking System," by R. F. Lucy et al, Sylvania Electronic Systems, 18 November 1965, which is available from:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10629

Patent status:

No patent action is contemplated by NASA.

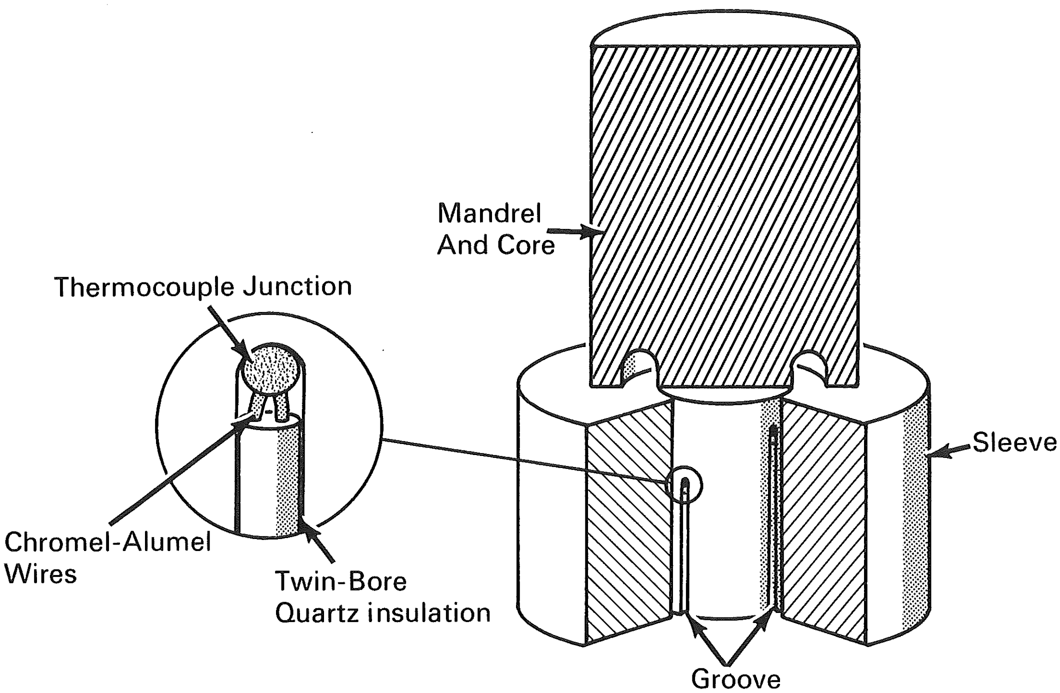
Source: R. F. Lucy, C. J. Peters,
E. J. McGann, and K. T. Lang
of Sylvania Electronic Systems
under contract to
Marshall Space Flight Center
(M-FS-1606)

December 1966

Brief 66-10632

NASA TECH BRIEF

Accurate Depth Control Provided for Thermocouple Junction Locations



An objective of a series of flight reentry experiments was to define the total heating on a blunt-nosed body of fairly large scale to provide data anchor points for comparison with results obtained from ground facilities and theoretical prediction methods.

The reentry package had a blunt forebody and conical afterbody. The maximum diameter was about 67 cm and the weight (mass) about 86 kg. Total heating was measured by use of calorimeter techniques. Since a usable calorimeter material could not be expected to last through the reentry heating period, a layered forebody construction was used. Three beryllium layers were heavily instrumented with thermocouples for use as calorimeters, and each layer provided total (convective plus absorbed radiative) heating data until surface melt occurred.

The thermocouple installations were designed to provide the minimum feasible disturbance of the local heat flow with a technique that provided accurate depth control of the thermocouple junction locations. Four chromel–alumel thermocouples were mounted at controlled depths in beryllium plugs

(continued overleaf)

which were inserted into the beryllium calorimeters.

The pertinent details of a thermocouple plug are shown. The thermocouple mounting core was machined on the end of a rod which served as a mandrel for handling and installation. The core and the sleeve were made from the same billet used for the beryllium dishes to insure identical material properties. Three thermocouple junctions were installed in grooves, the fourth junction was welded on the back face of the core. A weld bead was first formed on the small thermocouple wires and then resistance welded into the forward end of each groove. The distance from the mandrel shoulder to the center of each junction bead was measured under a microscope and recorded for every junction. The core was then pressed into the sleeve, with a shrink fit, until the mandrel shoulder was in contact with the finished face of the sleeve. Each thermocouple bead was made to protrude very slightly above the surface of the core so that the pressure of the sleeve would provide mechanical reinforcement of the marginal strength beryllium weld. Small ribbon-strip terminals of chromel and alumel were ceramic cemented into shallow grooves on the rear face of the sleeve. The thermocouple wires were welded to the inboard ends of these strips and the area was potted with ceramic cement to complete the plug assembly.

The plugs were installed in bored holes in the beryllium dishes as the final machine operation. Each plug was pressed into place with a shrink fit so that the face of the sleeve was flush with the adjacent surface of the beryllium dish. The mandrel was then machined off and the core face was hand finished flush with the sleeve surface. It is estimated that the distance from the calorimeter face to the center of each thermocouple bead was known with an error less than ± 0.05 mm after the final installation.

Note:

Additional details are contained in NASA Technical Note TN D-364, "Project Fire Instrumentation for Radiative Heating and Related Measurements", by Norman R. Richardson, October 1966, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virigina 22151—price $2.50. Inquiries may also be directed to:

Technology Utilization Officer
Langley Research Center
Langley Station
Hampton, Virginia 23365
Reference: B66-10632

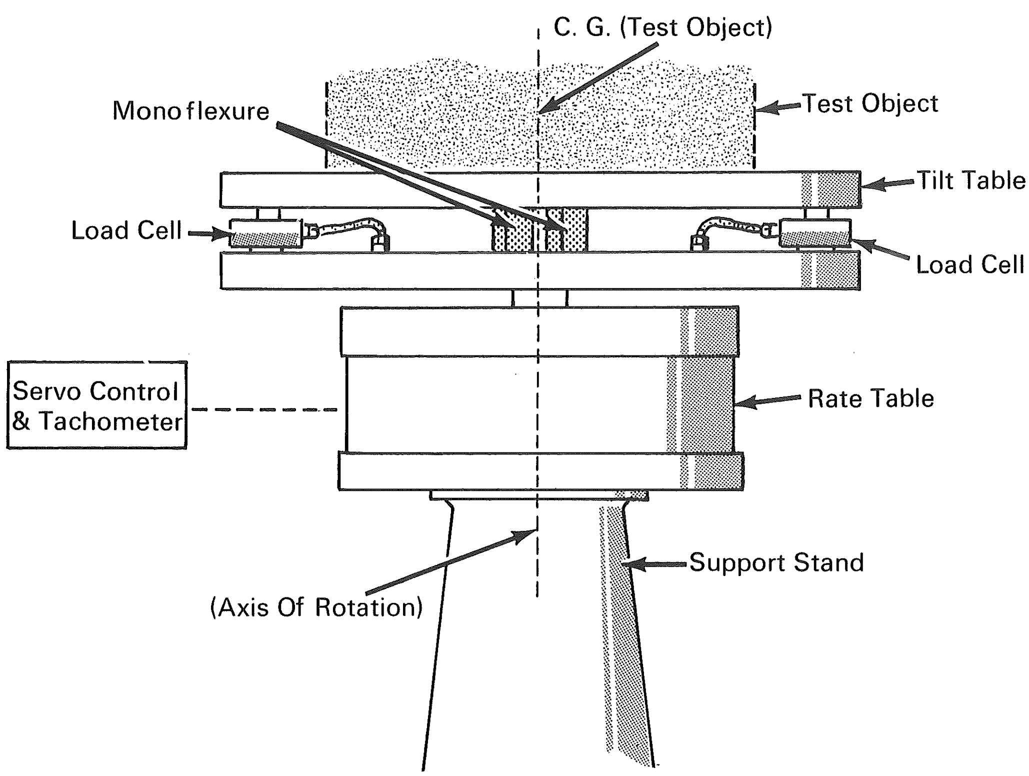
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C., 20546.

Source: Norman R. Richardson
(Langley-289)

NASA TECH BRIEF

Automatic System Determines Moments of Inertia of Asymmetrical Objects



The problem:

To provide a means of rapidly and accurately determining moments and products of inertia of asymmetrical objects.

The solution:

A system combining a torsional pendulum arrangement and a precision rate table with simplified analog computers to determine the desired quantities directly, without the need for additional calculations.

How it's done:

The test object is placed upon the tilt table of the torsional pendulum and oscillations are induced in the system. A sensor detects each passing of the system through the center position and generates a pulse for each complete cycle of oscillation. These signals, after appropriate amplification and shaping, are used to trigger a bistable multivibrator, which in turn controls the timing of a reference voltage to an integrator circuit in an analog computer. The integrator output

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is a voltage proportional to the oscillation period of the pendulum, which is then used to compute the moment of inertia of the object.

For computation of the product of inertia, the object is rotated about its center of gravity on the precision rate table. The servo control and tachometer provide an electrical analog of the angular velocity, and load cells attached to the rate table give an electrical output corresponding to the unbalanced axial forces induced by the rotation. These signals are processed in the analog computer to yield the numerical value of the product of inertia.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10636

Patent status:

No patent action is contemplated by NASA.

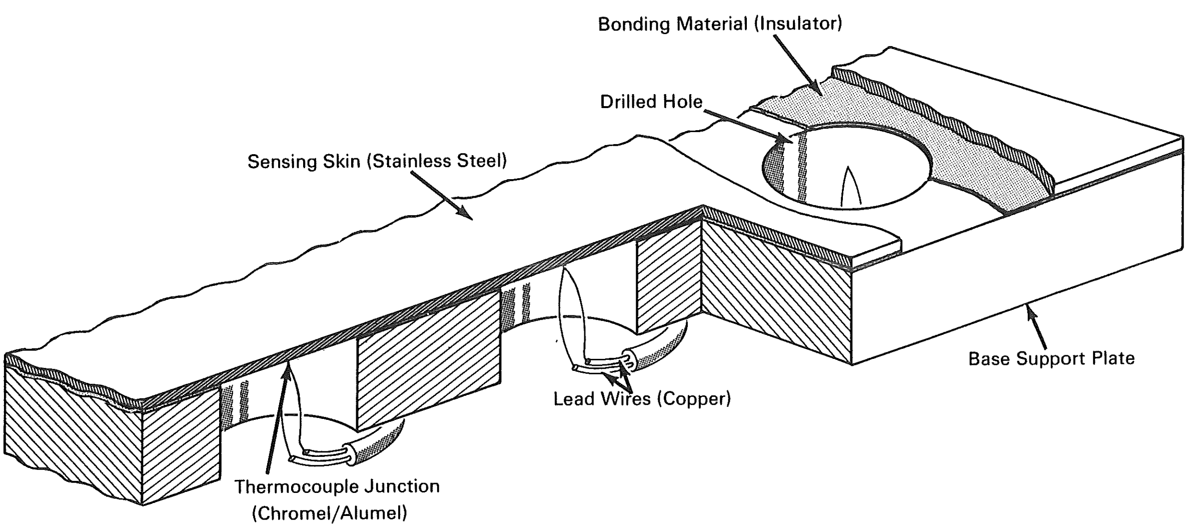
Source: Spaco, Inc.,
under contract to
Marshall Space Flight Center
(M-FS-1769)

December 1966 Brief 66-10637

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Instrument Accurately Measures Small Temperature Changes on Test Surface



The problem:

To devise an accurate method of measuring very small temperature rises (on the order of 1° to 2°C) occurring over time intervals of approximately 0.1 second on a test surface subjected to aerodynamic heating.

The solution:

The method involves the attachment of a continuous thin sheet of a sensing material to a base support plate (model body) through which a series of holes of known diameter have been drilled. When thermocouples are attached to the sensing material through the drilled holes, each disk of sensing material serves as an individual calorimeter.

How it's done:

The steel support plate, machined and ground smooth on one face, is drilled with 0.25-inch diameter holes at specified locations to accommodate the thermocouples. A 0.001-inch thick bonding material similar to double-backed tape is used under controlled temperature and pressure to attach the 0.002-inch thick 302 stainless-steel sensing skin to the support plate. This construction provides a smooth, uniform thin-skin surface, which serves as a calorimeter-type heat-transfer gage at each of the 0.25-inch hole locations. Chromel/alumel thermocouple wires (0.001-inch diameter) are then resistance welded onto the back side of the thin skin as near the center of the disks as possible. Copper lead wires of much larger

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diameter are joined to the 0.001-inch diameter thermocouple wires.

Notes:

1. The output signals from the thermocouples are of sufficient amplitude, so that the thermocouple lead wires can be directly connected to a sensitive galvanometer and oscillograph readout system.
2. This type of construction should be applicable to other geometries such as cylinders, wedges, and irregular shapes.
3. Further information concerning this instrument is given in NASA TN D-2846, "Effects of Leading-Edge Bluntness on Pressure and Heat-Transfer Measurements Over a Flat Plate at a Mach Number of 20", by William D. Harvey, October 1965, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151. Inquiries may also be directed to:

   Technology Utilization Officer
   Langley Research Center
   Langley Station
   Hampton, Virginia 23365
   Reference: B66-10637

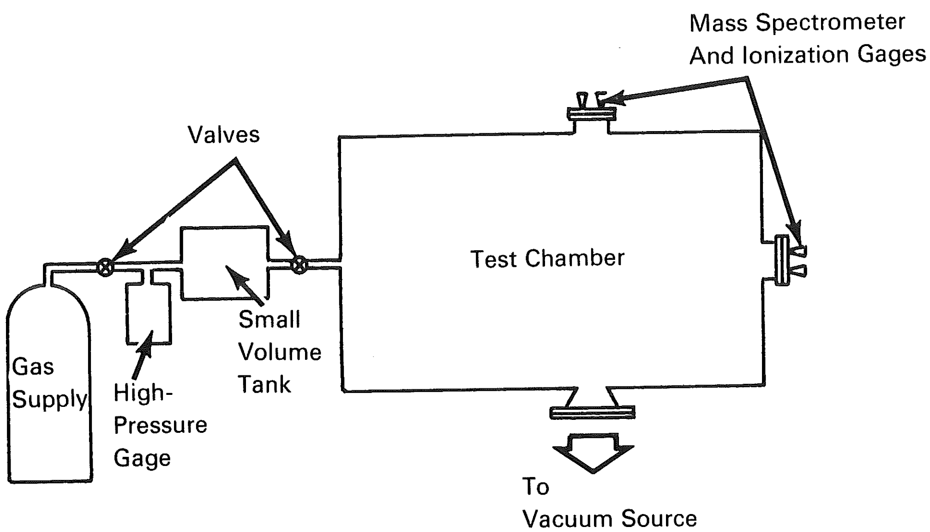
Patent status:

This invention is owned by NASA, and a patent application has been filed. Royalty-free, nonexclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D.C. 20546.

Source: William D. Harvey
and Howard B. Miller
(Langley-174)

NASA TECH BRIEF

Volume-Ratio Calibration System for Vacuum Gages



The problem:

To determine whether the expansion of a gas from a small volume into a large volume can be relied upon to create accurately known pressures in the range 10^{-7} to 10^{-3} torr, and thus provide a calibration medium for commercial vacuum gages in this range.

The solution:

A system consisting of a gas source, high pressure gage, small volume tank, large volume (test) chamber, plus appropriate piping, valves, and vacuum source. This system is used, in conjunction with commercial vacuum gages, to evaluate its ability to accurately produce desired pressures in the 10^{-7} to 10^{-3} torr range.

How it's done:

The test chamber is initially evacuated by the vacuum source to its ultimate pressure. Ionization gage readings become constant after an interval of gage outgassing. The small volume tank is evacuated and a quantity of the test gas is then valved into it from the supply, creating an initial pressure measured by the high pressure gage. The test chamber is sealed off from the vacuum source and the time is recorded in order to establish the elapsed time for the test. Rate of rise in the test chamber is observed for a period sufficient to establish the outgassing rate accurately. A given amount of gas in the small volume tank is valved into the test chamber and allowed to reach a state of equilibrium. Pressure in the small volume tank is recorded plus the readings of the ionization gages in the test chamber and the time of readings is noted. Tank wall and room temperatures are taken in order to include isothermal conditions in the calculations. This procedure is then repeated for a number of gas transfers in order to acquire a meaningful average.

(continued overleaf)

Notes:

1. Error analysis disclosed a limit of error from about 6% at 10^{-7} torr to 1% at 10^{-3} torr.
2. Five commercial hot filament ionization gages were calibrated in the 10^{-6} to 10^{-3} torr range in nitrogen gas. The results of 350 data points showed about 3% reproducibility in the gages—approximately equal to the readability factor of the gage indicators.
3. Further information concerning this innovation is presented in NASA TN D-3100, "Evaluation of a Volume-Ratio Calibration System for Vacuum Gages from 10^{-6} Torr to 10^{-3} Torr", by Raymond Holanda, November 1965, available from the Clearinghouse for Scientific and Technical Information, Springfield, Virginia 22151; price $1.00. Inquiries may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10640

Patent status:

No patent action is contemplated by NASA.

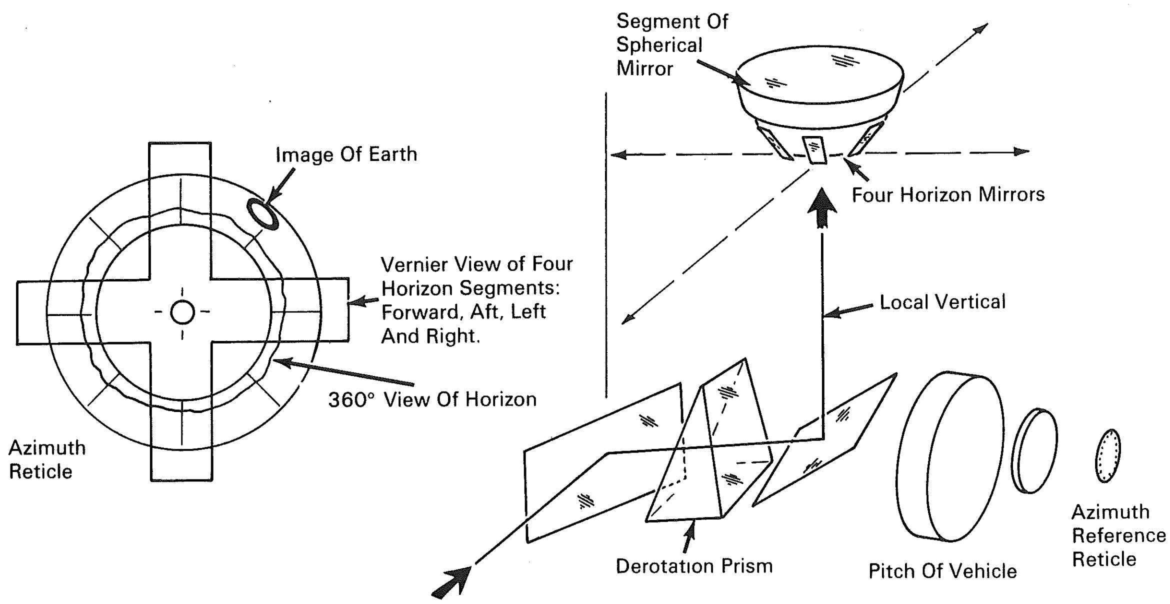
Source: (Lewis-303)

December 1966

Brief 66-10644

NASA TECH BRIEF

Three-Axis Attitude and Direction Reference Instrument Has Only One Moving Part



The problem:

Extreme weight limitations imposed on any lunar flying vehicle eliminate any but the most necessary instrumentation. Sophisticated navigational devices, radar units, and computerized coordinate systems generally require large installations and comparable power supplies. It is desirable that a very simple device provide a three-axis attitude reference and direction reference based on purely visual cues.

The solution:

A simple, single instrument combining the functions of attitude reference, direction reference, and display in a unit having only one essential moving element. The device, by use of a set of bubble levels and a calibrated dial, may be used as a sextant prior to takeoff, and as a backup navigation system during flight.

How it's done:

The lunar horizon is viewed by four mirrors set at 45° to the local vertical, oriented fore and aft, left and right. When the reference axis is vertical, the horizon will appear at the same location in each mirror. Above these four mirrors is a segment of a spherical mirror which, when the reference axis is vertical, will reflect the complete visual sphere except for occlusion by the lunar vehicle itself. Thus, it is guaranteed to pick up the moon-like image of the earth. The azimuth location of the image of the

(continued overleaf)

earth is the primary directional reference which is viewed around the circle of the horizon. An azimuth reference ring can be superimposed on the image of the horizon so that the heading of the vehicle can be read; or a command heading cursor can be included to indicate the proper heading to be maintained. This field of view must be presented to the astronaut despite the attitude of the vehicle while in motion. It is proposed that this be done by a pair of 45° mirrors or prisms, one directly in front of the astronaut and one which is rotated through the desired pitch angle by a knob graduated in degrees of pitch. This is the only necessary moving part. It is desirable to add a derotation prism which would be geared to rotate with ½ of the pitch command. For preflight survey use, the housing of the instrument would be leveled, as for example, by means of a ball swivel joint. The elevation angles to the earth and Polaris or any other pair of celestial points could be used to determine the position of the vehicle on the moon. A graphical computation or table can be used to determine the range and direction to the known position of the objective. The sight would then be rigidly attached to the frame of the vehicle, the desired pitch program angle set into the desired sight and the desired azimuth to the earth or Polaris dialed into the azimuth reference range. The astronaut would then have to fly the vehicle on the basis of visual cues until approximately in the proper direction, at which time he could transfer his attention to the attitude reference, as given by his sight.

Note:

This development is in conceptual stage only, and as of date of publication of this Tech Brief, neither a model nor prototype has been constructed.

Patent status:

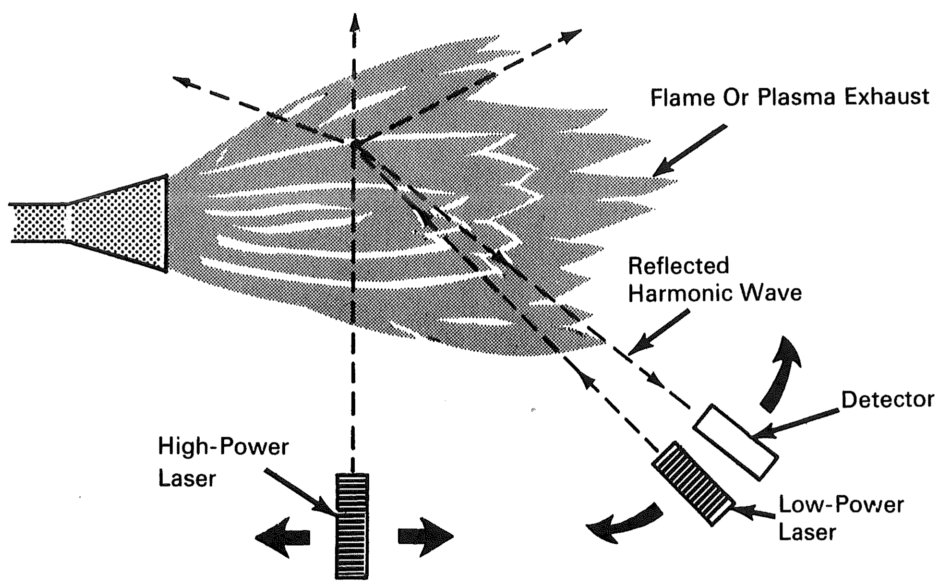
No patent action is contemplated by NASA.

Source: F. B. Bossler
of Bell Aerospace Corporation
under contract to
Marshall Space Flight Center

(M-FS-1819)

NASA TECH BRIEF

Concept for Using Laser Beams to Measure Electron Density In Plasmas



A concept is presented for using laser beams as a means of measuring electron density at various points in flame or plasma exhausts. This proposed laser application is based on the theoretical behavior of two plane waves propagating through a nonlinear medium, such as a plasma. Refraction of a low-power laser beam in a plasma would give rise to nonlinear polarized waves and a reflected harmonic wave from a point in the plasma. A measure of the electron density at this point would then be obtained by detecting the amplitude of the reflected harmonic wave. A second high-power laser beam would be used to create the abrupt dielectric change required in the plasma to provide a reflected wave of sufficient amplitude.

Note:

This development is in the conceptual stage only, and as of the date of publication of this Tech Brief neither a model nor a prototype has been constructed.

Patent status:

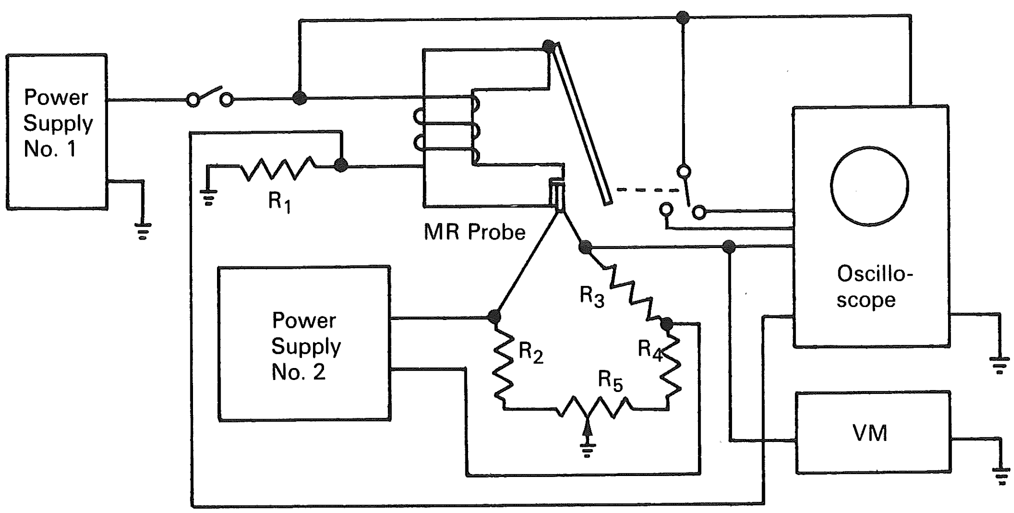
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Salvador E. Longo
of The Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-965)
Category 01

December 1966 Brief 66-10650

NASA TECH BRIEF

Magnetoresistor Monitors Relay Performance



The problem:

To monitor the action of relays without disturbing circuit parameters or degrading relay performance. Normally, relay performance monitoring has been limited to fully open or fully closed position indications plus coil circuit condition. Steady-state or transient position data cannot be obtained through current monitoring because the steady-state current is dependent only on the dc resistance of the coil.

The solution:

A technique that establishes the characteristic signature of a relay by measuring the magnetic flux produced under transient conditions.

How it's done:

A magnetoresistor is placed in a recess in the contact end of the relay core. This probe is operated by its own power supply and, through a bridge circuit, its reaction to change in relay magnetic flux is indicated on a voltmeter and displayed on an oscilloscope. By photographing the oscilloscope display, voltage and current conditions related to time are made available to determine the characteristic signature of a given relay. Such parameters as contact travel time, time for coil current to reach a steady-state condition, coil voltage condition, etc. afford a clear picture of relay operating characteristics.

(continued overleaf)

Notes:

1. Many malfunctions, such as lack of armature movements, friction, welded contacts, and low coil voltage may be determined from the transient waveforms.
2. This device permits relay monitoring with a single passive sensor that does not affect relay operation or reliability.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10650

Patent status:

No patent action is contemplated by NASA.

Source: Darrel Q. Krebs
of The Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-1754)

NASA TECH BRIEF

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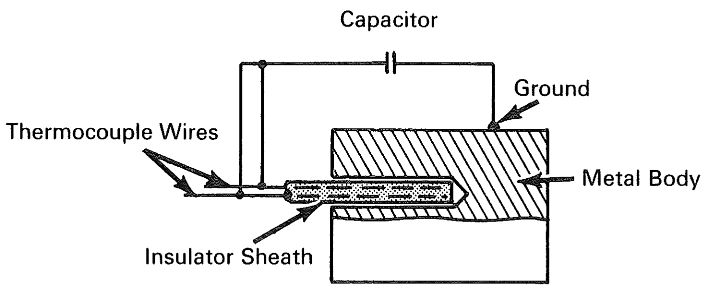
Thermocouples Easily Installed in Hard-To-Get-To Places



The problem:

To devise a method for installing thermocouple wires in places that are not accessible to hand-welding techniques. Previous methods, such as potting the thermocouple in a drilled hole, proved unsatisfactory because of uncertain contact.

The solution:

Thermocouple wires attached to charged capacitors are inserted in a drilled hole. An electric charge fuses the thermocouple wires to the host material.

How it's done:

A sufficiently large hole to accommodate the thermocouple wires and insulating sheath is drilled in the host material. The thermocouple wires are stripped, twisted together,and made to form a junction by using a mercury arc fusion welder. A bank of capacitors (or a percussion welding machine) is then attached to the thermocouple, with one side to the wires and the other grounded to the host material. The capacitors are then charged and the thermocouple is inserted in the drilled hole. An insulating sheath is used to prevent the thermocouple junction from touching the sides. The capacitors are discharged, forming an arc and causing the thermocouple wires to be fused to the host material, thereby eliminating any air gap between the thermocouple and the host material.

Notes:

1. This method has shown excellent results in fusing nichrome, chromel, Inconel, and stainless steel wires to nickel, beryllium, iron, steel, Inconel, and stainless steel.
2. Aluminum and copper can also be fused but not with a high degree of reliability.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10653

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

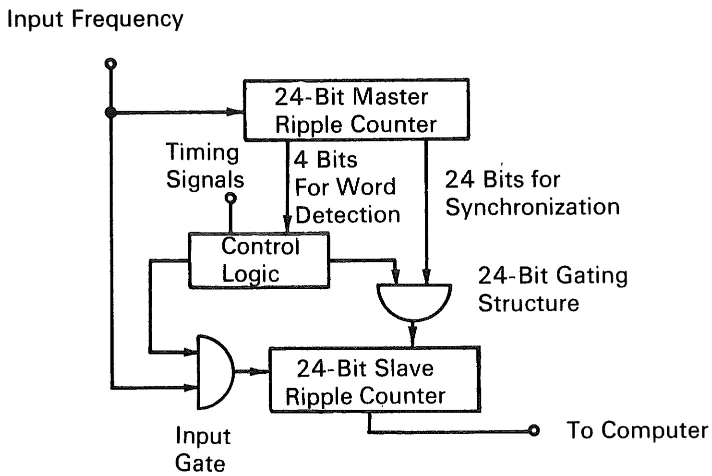
Source: F. G. Guenther
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1946)

Category 01

December 1966 Brief 66-10658

NASA TECH BRIEF

Digital Frequency Counter Permits Readout Without Disturbing Counting Process



The problem:

To devise a digital frequency counter that can be read out accurately at one-second intervals without interrupting or disturbing the counting process. This counter is to be used to monitor the frequency of a programmed exciter that serves as a local oscillator capable of providing frequencies from 0 to 50 Mc/sec in steps of 0.01 cps. Previous counters required an inordinate amount of gating logic and high circuit speed.

The solution:

A system incorporating a master counter and a slave counter with novel logic interconnections.

How it's done:

Two 24-bit ripple counters are used, one a master, and the second, a slave. Both counters count the input frequency, but in addition, the slave counter may either be synchronized to the master counter or disconnected from the input frequency by the control logic.

Sometime before the count value is desired, both the input signal from the input gate and the synchronizing signals from the master counter are connected to the slave counter. The synchronizing signals are fed directly into the dc inputs of the slave counter flip-flops, which are represented by the 24-bit gating structure. When a carry ripple is propagating down the master counter, the slave counter is in an indeterminate state because of possible interference between the synchronizing signals and the slave internal ripple signals. When no ripple is present in the master counter, the state of the slave counter is exactly that of the master counter. The control logic disconnects the synchronizing signals from the slave counter at a time when no ripple is in the master counter (since

(continued overleaf)

the ripple in the slave counter occurs at the same time as the ripple in the master counter). The condition of no-ripple exists when the first 4 least significant bit positions of the master counter are equal to 1, indicating that 15 counts of the input frequency have occurred after the previous major carry bit has been propagated. Sufficient time has thus been allowed for all carries to have been completely propagated. At this time both counters are counting the same signal and contain the same count, but otherwise are completely independent of each other. When the instantaneous count value is desired, the input signal is disconnected from the slave counter. After any carry ripples have finished propagating in the slave counter, the individual slave counter flip-flops may be read by the computer.

Notes:

1. The counter can be readily adapted to provide frequency readouts at 0.1 second intervals.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10658

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Robin Winkelstein
(JPL-906)

NASA TECH BRIEF

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Logic Circuitry Used to Automatically Test Shielded Cables

The problem:

In assembling multiple shielded conductors, a conductor is sometimes connected to a pin to which the conductor shield should be connected and vice versa. Additionally, a conductor in one shield may be connected to a pin to which another conductor in another shield should have been connected. After the connector assemblies have been properly potted, normal cable checking procedures do not reveal such errors.

The solution:

An automatic cable tester that uses logic circuitry to sequentially test all conductors and their shields to reveal any connection error in a GO–NO GO test.

How it's done:

An audio frequency (600 cps) generator is connected between an isolated common and any conductor in the cable with a logic indication of the specific conductor. A signal sensor, with an input impedance greater than one megohm, is connected between the common and any conductor except the one that the signal generator is connected to. A logic indication shows which conductor the sensor is connected to and the sensor gives a logic GO–NO GO indication to show receipt or nonreceipt of the 600 cps signal. A ground is used to connect the common to any shield, and logic indication shows which shield is contacted. Logic circuitry is used to connect the signal generator, sensor, and ground sequentially to each shielded conductor assembly until the entire cable is tested. The logic uses three solenoid driven stepping switches to operate a panel of indicator lamps that show which conductors and shields are connected and whether or not the sensor is receiving the 600 cps signal.

The sensor receives a signal if:

1. The signal generator and sensor are connected to conductors that are both in the same shield, no matter what shield is connected to common.
2. The signal generator and sensor are connected to conductors that are in different shields and common is not connected to either of the shields concerned.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Headquarters
National Aeronautics and Space Administration
Washington, D.C. 20546.
Reference: B66-10659

Patent status:

No patent action is contemplated by NASA.

Source: George Dibb
of General Electric Company
under contract to
NASA
(Hq-60)

Category 01

December 1966

Brief 66-10661

NASA TECH BRIEF

Study of Fast Response Thermocouple Measurement of Temperatures in Cryogenic Gases

To obtain a fast response from a temperature sensor, the heat capacity of the sensing element must be small in relation to the heat transfer to the element. Also, the element must be thermally isolated from its supports. The first of these requirements is met by a small diameter thermocouple wire. The second requirement can be met by making the leads of sufficient length so that the heat conduction down the leads is small and assuming that the leads adjacent to to the junction are subjected to the same thermal conditions. On other sensors that were considered, the mountings were generally large and thermally too close to be considered acceptable. Platinum wire resistance probes were considered but they required a four-wire lead system to eliminate the error due to lead resistance changes. Also the sensor element "averages" the temperature between the sensor wire supports and is affected to a considerable degree by heat transfer to the supports. Although the smallest thermocouple wire used will give the fastest response time, this program was restricted at the onset to a wire size considered large enough to withstand gas velocities up to 30 feet per second.

The basic configuration tested is known as the slingshot type and consists of a Y-shaped frame supporting the thermocouple and its leads. The following is a list of variables which were investigated for their effects on response time.

1. The thickness of a teflon slingshot frame.
2. A slingshot frame made of 18 gage thermocouple wire.
3. Dimensions of the slingshot frame.
4. Thermocouple junction weld.
5. Welds on lead wires in relation to the frame.
6. Angles formed by the thermocouple junction.
7. Relation of the thermocouple to the horizontal during testing.
8. Effect of insulation and varnish.
9. Cleaning of the thermocouple wire at the junction.
10. Speed of probe being removed from liquid.

The results indicate that durable thermocouples can be made in quantity and have fast reproducible response times. Such thermocouples should be fabricated from uninsulated small diameter wire. The thermocouple should be mounted in a lightweight wire slingshot frame with support distance 3 inches or more. The thermocouple leads should form an included angle of about 75° (the bead about 2 inches beyond the ends of the frame arms). The frame should be mounted so the plane of the supports is about 30° above horizontal. The thermocouple junction should be made by welding with excess wire carefully trimmed away.

Note:

Additional details are contained in the Beech Aircraft Corporation report, "Fast Response Thermocouple for Measurement of Temperatures in Cryogenic Gases," by C. C. Robinson, et al, October 12, 1964, which is available from:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10661

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: C. C. Robinson, A. R. Lowrie,
and T. Bielawski
of Beech Aircraft Corporation
under contract to
Marshall Space Flight Center
(M-FS-1659)

NASA TECH BRIEF

Packaging of Electronic Modules

A study has been made of design approaches that can be taken toward optimizing the packaging of electronic modules (such as cordwood modules and printed circuit cards) with respect to size, shape, component orientation, interconnections, and structural support. The study gives consideration to the geometry of two- and three-dimensional modular arrays from the standpoint of implementing their subassembly and packaging by simple automatic machines.

Notes:

1. The study does not present a solution to specific packaging problems, but rather delineates the factors that should be considered in efforts to achieve optimum packaging designs.
2. Inquiries concerning this study may be directed to:
   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10664

Patent status:

No patent action is contemplated by NASA.

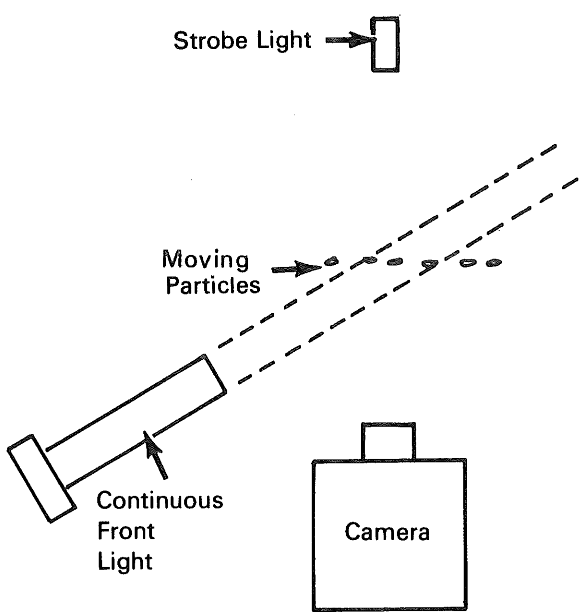
Source: Leonard Katzin
(JPL-801)

Category 01

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Photographic Method Measures Particle Size and Velocity in Fluid Stream



The problem:

To devise a means of determining the size and velocity (in the range from Mach 0.5 to 1.0) of small particles in nonturbulent fluid streams.

The solution:

A method employing a nonframing motion picture camera, a continuous front light source, and a strobe light.

How it's done:

The optical axis of the camera is positioned at right angles to the stream flow. A continuous light source is placed to illuminate the front of the stream, and a strobe light is placed on the opposite side of the stream.

When a particle illuminated by the continuous light source moves across the camera lens, a light streak or velocity trace is produced on the moving film. The strobe light produces an image or shadow of the particle at regular time intervals on the velocity trace on the film. The velocity of the particle is calculated from the known film travel speed and the slope of the trace on the developed film. The size and shape of the particle at the calculated velocity are determined by measurement of the particle image produced by the strobe light, taking into account the geometrical relationships of the system.

(continued overleaf)

Notes:

1. This method of measurement should be of interest in the study of the motion of solid and liquid particles in research and industrial fluid flow systems.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10668

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: R. A. Dickerson
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1536)

December 1966 Brief 66-10669

NASA TECH BRIEF

Gas Leak Detector is Simple and Inexpensive

The problem:

To devise a simple, inexpensive system to continuously monitor for small gas leaks in piping or pressure vessels that are remotely located or located in an environment that is hazardous to personnel. Previous methods have required either continuous monitoring by personnel or expensive instruments and systems or both.

The solution:

A combination of a paper ribbon and adhesive plastic tape is used to cover the area to be monitored and a pressure sensor is placed over a hole in the tape and paper. The pressure sensor consists of an upper and a lower diaphragm, protective covers, and adhesive-faced spacers to hold the components in place. Leaks move under the paper and tape and reach the sensor, which is actuated by the rise in pressure beneath it. The sensor response causes an audible and/or visual indication at a central control point remote from the detector location.

Notes:

1. This system is advantageous because of its inexpensive and simple construction and because it lends itself to monitoring any gas regardless of its nature.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10669

Patent status:

No patent action is contemplated by NASA.

Source: D. K. Mitchell
of the Boeing Company
under contract to
Marshall Space Flight Center
(M-FS-1206)

Category 01

December 1966 Brief 66-10670

NASA TECH BRIEF

Computer Program Determines Chemical Composition of Physical System at Equilibrium

The problem:

In the course of study of any physical system in which chemical reactions play an important part, it is desirable to know the chemical composition of the system at thermodynamic equilibrium. The equilibrium chemical composition may indicate the maximum yields of the system obtainable under a given temperature and pressure, or it may reveal the maximum energy exchange possible. The classical approach to this problem is to examine the various chemical reactions involved and set up a group of nonlinear simultaneous equations based on the equilibrium constants, the temperature and pressure of the system, and the elemental mass balances. With even moderately complex systems, the resulting set of simultaneous equations is too difficult to solve to be practical.

The solution:

A digital computer program written in FORTRAN IV for the IBM 7094 for the calculation of the equilibrium composition of complex, multiphase chemical systems.

How it's done:

This program is based on the concept that at thermodynamic equilibrium the free energy of the system is at its minimum. Hence this method is known as the free energy minimization method. With this method, the equilibrium of each individual chemical reaction is not considered as such. Instead, attention is focused on the chemical potentials or the free energies of the possible species. The distribution of these species is then established by minimizing the total free energy of the system. By this technique, the solution of the problem is reduced to mere mathematical operations, without concern for the chemistry involved.

The program is very general and may find applications in diversified areas. It is designed to cover a maximum of 12 elements in 80 gaseous and 15 condensed species. The elements included in the program are C, O, H, N, Si, A, Al, B, and Ca. The temperature range is 0 to 24,000 degrees K. Also certain thermodynamic properties of the system are determined as byproducts of the main calculations.

Note:

Additional information is contained in North American Aviation, Inc. Report, "Digital Program Description for APD 104," SID 65-45, April 30, 1965, which is available from: COSMIC
Computer Center
University of Georgia
Athens, Georgia 30601
Reference: B66-10670

Patent status:

No patent action is contemplated by NASA.

Source: S. S. Kwong
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-1119)

Category 01

December 1966 Brief 66-10671

NASA TECH BRIEF

Computer Program Determines Chemical Equilibria in Complex Systems

The problem:

To solve numerically, nonlinear algebraic equations describing chemical equilibria in complex systems.

The solution:

A computer program for chemical equilibrium computations based on iteration equations that are independent of choice of components.

How it's done:

The NASA Lewis Research Center has developed a computer program for the IBM 7090 or 7094 written in FORTRAN IV for the computation of chemical equilibria in complex systems with several applications. The program permits iteration equations to be written in a form independent of the choice of components. The program can perform the following calculations:

1. chemical equilibrium for assigned temperatures and pressures,
2. theoretical rocket performance for both frozen and equilibrium composition during expansion; and
3. Chapman–Jouguet detonation properties.

The objective has been to develop a program that can compute equilibrium compositions for any chemical system for which thermodynamic data exist. To accomplish this objective, several special techniques were incorporated to handle problems that would otherwise not converge. These techniques, which have proven successful in the many problems attempted, include a flexible convergence control parameter and automatic inclusion of condensed species with the possibility of triple points. A discussion of some of the problems attendent with the presence of condensed species as reaction products is also given.

Notes:

1. The following are some of the program's general features: It requires only a simple input and no initial estimates. It handles up to 15 chemical elements and a total of 90 reaction products including condensed species.
2. The computer program can be used to analyze and study combustion processes and design hardware such as furnaces, combustion engines, chemical reactors, etc.
3. Additional information is contained in NASA Technical Note D-1454, "A General IBM 704 or 7090 Computer Program for Computation of Chemical Equilibrium Compositions, Rocket Performance, and Chapman–Jouguet Detonations," by F. J. Zeleznik and Sanford Gordon, October 1962. Inquiries concerning this innovation may also be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B66-10671

Patent status:

No patent action is contemplated by NASA.

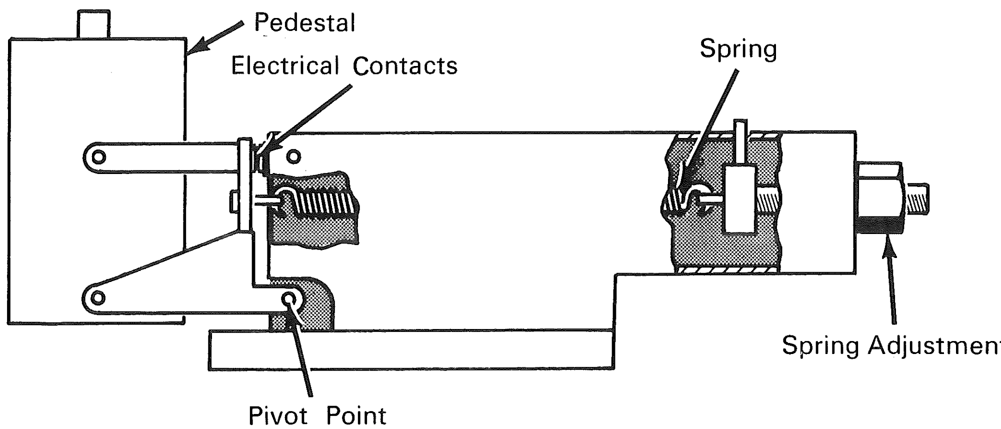
Source: Frank J. Zeleznik and Sanford Gordon (Lewis-281)

Category 01

December 1966 Brief 66-10675

NASA TECH BRIEF

Gage Accurately Controls Force for Placing Chips on Substrates



The problem:

To develop a device to control the force used in manually placing chips on substrates. The device must precisely control the compression load between 2 small members at loads as low as 25 grams.

The solution:

A chip placement force control gage that is preset by varying the spring deflection.

How it's done:

The module is placed in a holder and placed on top of the pedestal. The chip is manually placed on the module. A force is applied to the top of the device and the pedestal starts a downward movement. This is sensed through the electrical contacts which are in series with a signal light within the operator's view. When the preset placement force is reached, the contacts open. This preset force varies with the specific component. A signal light informs the operator that the proper load has been reached.

Notes:

1. The gage is accurate to within 5% at a 50-gram load. Since the inaccuracy is a function of the spring override, it may be further controlled by replacing the spring with a counterweight.
2. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10675

Patent status:

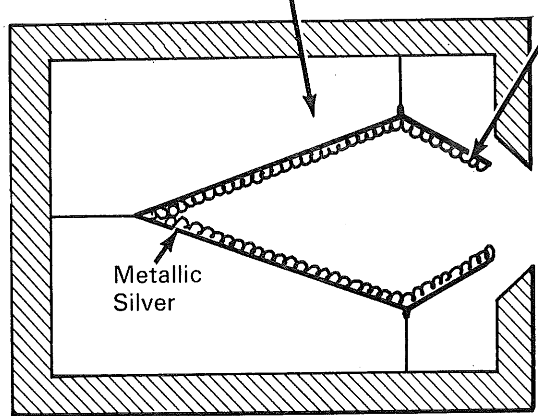
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

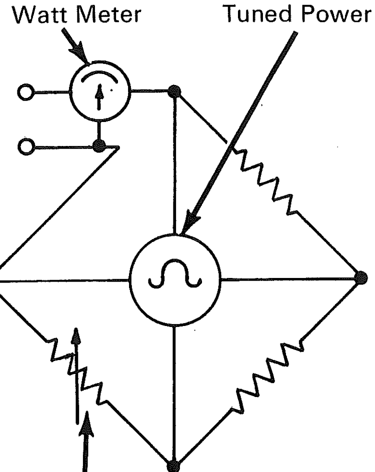
Source: W. P. Benzie
of IBM
under contract to
Marshall Space Flight Center
(M-FS-1941)
Category 01

December 1966 Brief 66-10679

NASA TECH BRIEF

Blackbody Cavity Radiometer Has Rapid Response





The problem:

The absolute measurement of radiant energy; for example, the determination of the sun's constant, or the output of a tungsten lamp, or optical manochromator.

In the field of spectroscopy it is often necessary to calibrate rapidly responding photodetectors against a standard reference detector. This is done by alternately illuminating the unknown photodetector and reference standard with a suitable light switching system (chopper). In addition to having very slow response, presently available standard detectors must themselves be calibrated against a light source whose output is determined by calculation. Presently available chopping rates are at best only 10 cycles per second when a rate of several thousand is desired.

The solution:

A fast response, spectrally linear standard detector in the form of a blackbody cavity radiometer. It is an isothermal rate calorimeter in which the rate of heat generated (wattage) from an unknown light source is directly compared with that generated from a measured electrical source.

How it's done:

The radiometer sensitive element is illustrated in the left sketch. A bifilar-wound resistance thermometer is wound in the shape of a conical cavity and encased in a highly conductive material such as metallic silver on the outside to impart thermal equilibrium. The inner part of the resistance thermometer is coated with a conductive black material such as electrolytically deposited platinum black to enhance radiant absorptivity.

(continued overleaf)

In one version, the complete sensitive element is suspended by small quartz fibers within a housing whose temperature is maintained constant by virtue of its own thermal mass or by applied control.

If applied in the conventional manner, the sensitive element as described above would be used to monitor radiant energy by measuring its increase in temperature (resistance change) when light from an unknown source enters it. This would require the usual calibration to establish sensitivity as well as involve a time of several seconds.

In this invention, the cavity shell is held to very constant temperature (higher than its housing) by placing it in a bridge temperature control circuit illustrated in the right figure. Radiant energy is monitored by measuring the electrical wattage decrease necessary to maintain temperature control when light from the unknown source is introduced. The resulting response time is equal to that mentioned above divided by the gain of the amplifier. Since amplifier gains of 10^6 are possible, response times of fractions of a millisecond are possible. No separate calibration is necessary since the electrical wattage may be read directly from the wattmeter.

Notes:

1. In other forms the device may be used as an accurate source of blackbody radiation or as a remote temperature sensor.
2. Inquiries concerning this invention may be directed to: Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10679

Patent status:

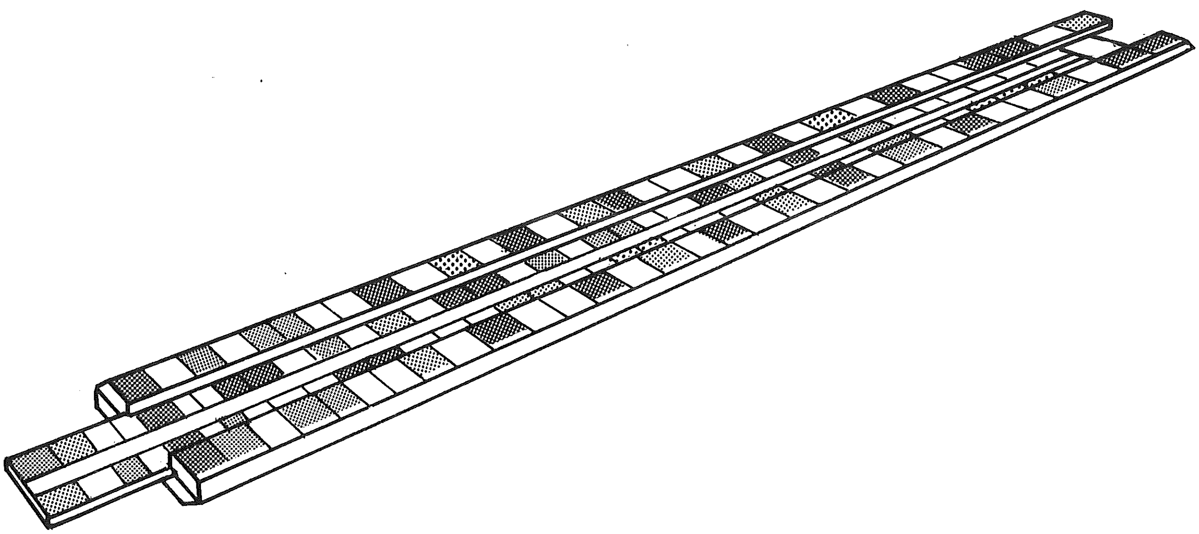
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Floyd C. Haley
(JPL-521)

December 1966 Brief 66-10680

NASA TECH BRIEF

Slide Rule-Type Color Chart Predicts Reproduced Photo Tones



The problem:

In the production of briefing charts that are photographed in black and white, it would be advantageous to be able to determine the final reproduced gray tones in order to achieve a pleasing and effective contrast as between superior and subordinate chart increments.

The solution:

A slide rule-type color chart that shows both the color by drafting paint manufacturer's name and mixture number, and by the gray tone resulting from black and white photographic reproduction.

How it's done:

The selection of colors necessary to produce sufficiently contrasting gray tones is made quickly and easily by moving the rule slide and visually comparing the various gray tones as they register adjacently. As the desired contrast is determined, the appropriate color identification by manufacturers' names and hues is read from the rule. The names and corresponding hues of the various manufacturers appear on the rule above and below the various gray tones.

Notes:

1. This rule might be useful for commercial artists to assist in selecting specific colors to produce desired photographic tone contrast.
2. Inquiries concerning this innovation may be made to:

   Technology Utilization Officer
   Manned Spacecraft Center
   Houston, Texas 77058
   Reference: B66-10680

(continued overleaf)

Patent status:

No patent action is contemplated by NASA.

Source: J. D. Griffin
of North American Aviation, Inc.
under contract to
Manned Spacecraft Center
(MSC-1227)

NASA TECH BRIEF

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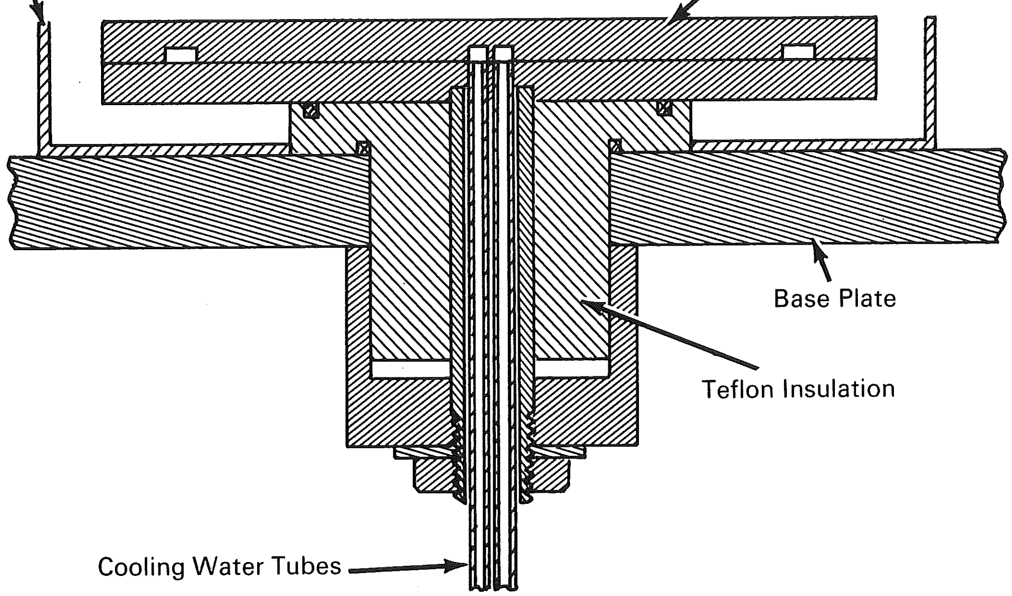
Process Reduces Secondary Resonant Emission in Electronic Components



The problem:

The requirement to significantly increase the power output of transmitters used on interplanetary probes has stimulated research into methods of reducing secondary electron emission (multipaction) in coaxial connectors and in waveguides. Unpressurized rf systems are desirable because equipment is less complex and lighter in weight and because of the danger of pressure loss that can result in system failure where such a system of multipaction prevention is used. The technique of coating with titanium reduces multipaction in vacuum but does not appreciably affect it after exposure to the atmosphere.

The solution:

After the assembly to be treated has been cleaned of all contaminants, it is placed in a vacuum chamber and the negative lead of a high voltage supply (nominally 5 kv) is applied to the assembly while the positive lead is applied to ground. The chamber is now evacuated to approximately 10^{-6} torr and argon gas is introduced into the chamber until the assembly glows evenly. The argon feed is terminated and a hydrocarbon gas such as methane is introduced which disassociates in the discharge to form a thin carbon film causing the glow to disappear after about one minute, at which time the high voltage is removed and the chamber is vented to the atmosphere.

(continued overleaf)

Notes:

1. Apparatus required for this process is standard except for the water cooled etching table whose teflon insulated bearing permits the high voltage application.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10685

Patent status:

No patent action is contemplated by NASA.

Source: H. Erpenbach
(JPL-934)

December 1966 Brief 66-10687

NASA TECH BRIEF

NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Study of Hot Wire Techniques in Low Density Flows with High Turbulence Levels

Large turbulence levels in the separation and reattachment regions of free shear layers produce severe heat fluxes that emphasize the urgent need for a technique that will allow an experimental determination of turbulent properties. The prediction of heat, mass, species, and momentum fluxes in a space vehicle and a more detailed understanding of aerodynamic noise production by supersonic jet and rocket exhausts require a predictability of the associated turbulence fields.

Flow phenomena and heat transfer have been studied behind a blunt trailing edge in a two-dimensional, supersonic shear with a turbulent forebody boundary layer.

To date, the hot wire is the only instrument that has been applied successfully to turbulence investigated in shear layers. The proposed measurements are, however, unusual since the rms levels in the recirculation zones of interest might very well be so large that they are comparable to the mean value.

A review of hot-wire heat loss equations indicates that a time invariant frequency response can be obtained at high turbulence levels only if the probes are operated at a constant temperature. The static calibration of two modern constant-temperature hot-wire systems combined with hot-wire and hot-film sensors was used. The two systems were a modified Kovasznay circuit and the DISA anemometer. These calibrations showed significant changes at low densities approaching one percent of atmosphere. Also, there was a large increase of wall proximity effects at low densities. At a pressure of approximately 0.1 atmosphere, the effect of a wall at room temperature is detectable at approximately 1000 hot-wire radii.

Considerable changes were found to occur in the slope of the wire resistance temperature relation. This is especially true at low temperatures. These changes are attributed to impurities and results of the mechanical drawing process which make it necessary to repeat the resistance-temperature calibration for each consignment of wire.

A summary of the extensive static and dynamic calibrations of modern hot-wire systems that might be used in low density flows with high relative fluctuation levels is contained in a technical report, "Hot Wire Techniques in Low Density Flows with High Turbulence Levels," by A. R. Hanson and R. E. Larson of Litton Systems, Inc., and F. R. Krause of Marshall Space Flight Center. The report is available from:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10687

Patent status:

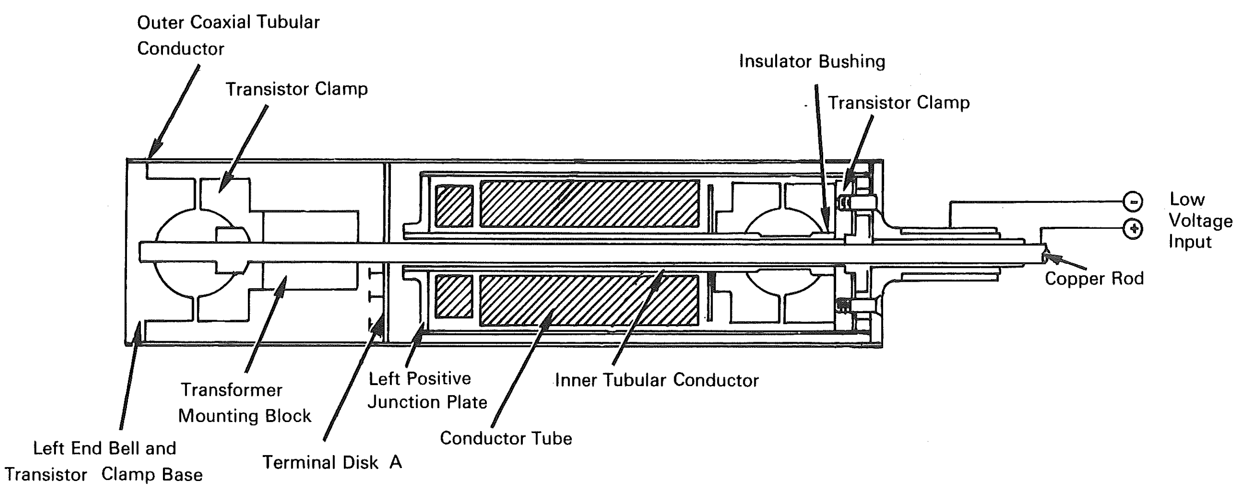
Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: A. R. Hanson, R. E. Larson
of Litton Systems
F. R. Krause
of Marshall Space Flight Center
(M-FS-1269)

Category 01

NASA TECH BRIEF

Low-Input Voltage Converter/Regulator Minimizes External Disturbances



The problem:

To develop a lightweight, low-voltage dc to high-voltage dc converter with minimum external magnetic field disturbance. The device is to be used to convert the output of fuel and solar cells, thermionic diodes, thermoelectric generators, and high-performance single-cell electrochemical batteries to a 28 vdc output.

The solution:

An efficient, low-input voltage converter/regulator constructed in a coaxial configuration. The coaxial design minimizes external magnetic field disturbance, suppresses radio noise interference, and provides excellent heat transfer from power transistors.

How it's done:

The coaxial-design converter mounts transistors at each end for optimum heat transfer to the converter's cylindrical outer surface.

The rod type conductor and the inner tubular conductor are fabricated from copper to provide maximum conductivity, which minimizes the conductor cross-sectional area required for efficient conversion of low-voltage, high-current power. The heavy primary currents travel a completely coaxial path in that they pass once through the center of the transformer cores and then return on the outer surface of the transformer by means of concentric coaxial tubular conductors. This arrangement produces zero external magnetic disturbance because the equal and opposite concentric current flow tends to cancel the magnetic fields generated by current flow in each respective direction.

The various transformer secondary windings are twisted pairs as they leave the transformer. These leads terminate at terminal disk A. The terminals on disk A are positioned so that the terminating points

(continued overleaf)

for the respective leads carrying equal and opposite currents are placed close together. This proximity minimizes the effective current loop that is capable of generating noncancelling magnetic fields. The lead wires that are brought out of the converter are also connected to these terminals. These leads are either coaxial or triaxial conductors, depending on the magnetic field cancellation requirements of the respective current paths. Hence, the twisted pairs, terminal spacing, and coaxial output leads minimize the magnetic disturbance that may be generated by the current flowing between the transformer, voltage regulator, and output circuitry. These leads exit at the left end-bell and are connected to the voltage regulator assembly.

The remaining electrical conductive paths such as the outer coaxial tubular conductor, conductor tube, and the transistor clamps are fabricated from tin-plated aluminum to provide good contact surfaces for both soldered and press fit joints.

To minimize the number of leads leaving the converter, some components such as signal rectifiers, decoupling transformers, and switching reactors are internally mounted on the terminal disk and the transformer mounting block. This reduces the number of lead wires leaving the converter and lessens the complexity of lead routing.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10689

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: Honeywell, Inc.
under contract to
Goddard Space Flight Center

(GSFC-527)

NASA TECH BRIEF

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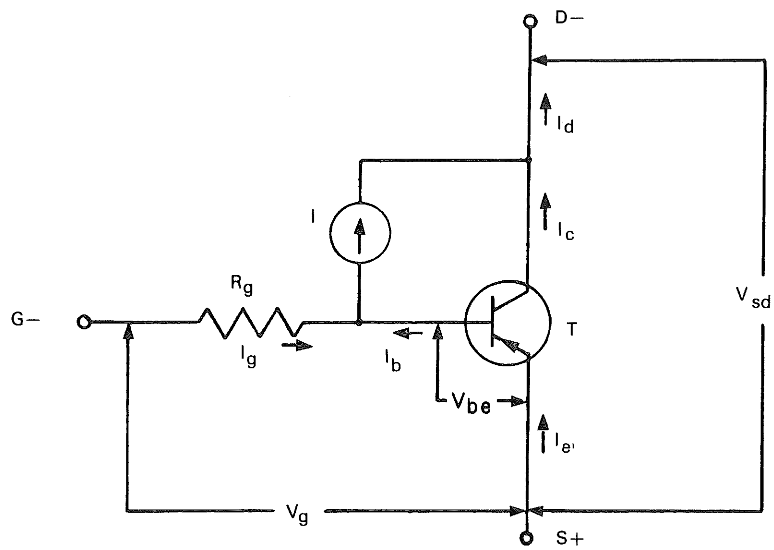
Equivalent Circuit for a Field Effect Transistor Established for Computer Simulation



The problem:

To provide a computer simulation for a field effect transistor. Existing computer programs which perform automated electrical circuit analyses and syntheses are only able to simulate resistors, voltage and current sources, diodes, capacitors, inductors, and conventional transistors.

The solution:

An equivalent circuit for the field effect transistor made up of circuit elements which can be simulated by existing computer programs.

How it's done:

The field effect transistor equivalent circuit consists of a conventional transistor (T), a resistor (R_g), and a constant current source (I). The terminals S, G, and D correspond to the source, gate, and drain terminals of the field effect transistor. The value of R_g is made to be the same as the gate input resistance. The value of I must be calculated from the electrical characteristics of the field effect transistor. Transistor T will be a PNP type for a P-type channel field effect transistor, and an NPN type for an N-type channel. Because computer programs simulate transistors by the I_c vs V_{be} characteristic curve, the values for I_c, V_{be} and β must be calculated for the transistor.

Depending on the accuracy required by the application, improvements to the model may be made by including some or all of the factors which influence

(continued overleaf)

performance characteristics of the field effect transistor. These factors are:

1. Adjust the characteristics of the base-collector junction to improve the drain current curve in the pinch-off region.
2. Vary the value of R_g with variation in V_g to cause the slope of the drain current curve to vary with gate voltage.
3. Vary both R_g and β with temperature.
4. Vary β with drain current.

These factors may also be described by curves in the computer program instead of by fixed parameters.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10690

Patent status:

No patent action is contemplated by NASA.

Source: L. J. Ming
of International Business Machines, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1752)

NASA TECH BRIEF

Solid-State Recoverable Fuse Functions as Circuit Breaker

The problem:

To develop a device that protects electronic circuits during overload conditions, and then permits them to continue to function immediately after the overload condition is removed. This is to be accomplished without the use of either one-time fuses or conventional type circuit breakers.

The solution:

A molded, conductive-epoxy recoverable fuse that incorporates low resistance at ambient (room) temperature, and high resistance at an elevated temperature. The fuse is capable of quickly switching back and forth from low to high resistance depending upon the current and temperature to which it is subjected.

How it's done:

The recoverable fuse consists of an epoxy resin that is mixed with a conductive powder, and then molded to the desired size and shape. The material used in fabricating the recoverable fuse is known as a "conductive resin," an epoxy filled with a suitable conductive powder. The powder changes the insulating characteristics of the epoxy to those of an electrical conductor. For example, when specific epoxies having certain thermal coefficients of expansion are mixed with silver plated copper powder, the resulting conductive resin (epoxy) exhibits unique thermoelectrical characteristics. The principal characteristic is that the resin is rendered highly conductive (less than 0.1 ohm) below a critical temperature, and highly nonconductive (more than 100 megohms) above that temperature. Consequently, the transition from low to high resistance is extremely rapid. This results in a repeatable switching action that is readily adaptable for use in electronic circuits.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10691

Patent status:

No patent action is contemplated by NASA.

Source: E. F. Thomas, Jr.
(GSFC-560)

Category 01

December 1966

Brief 66-10692

NASA TECH BRIEF

Hermetically Sealed Cells Protected from Internal Gas Pressure

The problem:

To prevent damage to hermetically sealed nickel–cadmium secondary cells by buildup of gas pressure during overcharging and reversed charging conditions.

The solution:

The cells are manufactured with less charge capacity in the positive electrode than in the negative electrode, and two additional electrodes are added; one to detect the evolution of oxygen during overcharge at the positive electrode, the second to recombine hydrogen evolved at the positive electrode during overdischarge. The second electrode is connected to the negative electrode by a diode which disconnects it during normal charge and discharge conditions.

How it's done:

During normal charge, no gas is evolved at either electrode. When the positive electrode becomes fully charged it generates oxygen. The oxygen is detected by the first auxiliary electrode which develops a control signal to the battery charging power supply.

During normal discharge no gas is generated at either electrode. When the smaller capacity positive electrode has discharged, current continues to flow due to the potential of series-connected cells still having some charge remaining. This causes overdischarge of the positive electrode so that it generates hydrogen:

$$2H_2O + 2e \rightarrow 2OH^- + H_2$$

This hydrogen is recombined by the second auxiliary electrode during overdischarge:

$$H_2 + 2OH^- \rightarrow 2H_2O + 2e$$

the electrons being fed to the external circuit. Thus, no permanent buildup of hydrogen occurs in operation, and the cell cannot be harmed by prolonged overdischarge.

An additional benefit is the capability to erase the memory effect displayed by NiCd batteries when employed at lower than full capacity. This is accomplished by periodically subjecting the battery to overdischarge for a short time.

The use of two auxiliary electrodes can be applied to other alkaline type cells such as silver–cadmium and silver–zinc.

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Goddard Space Flight Center
Greenbelt, Maryland 20771
Reference: B66-10692

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

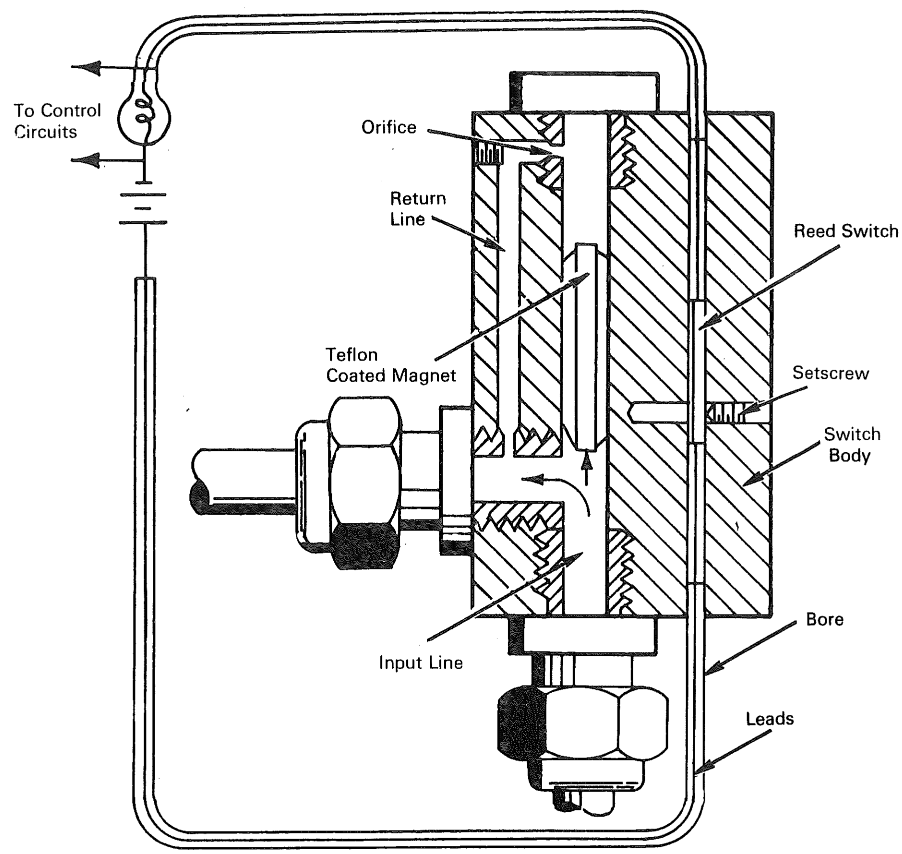
Source: W. N. Carson
of General Electric Company
under contract to
Goddard Space Flight Center
(GSFC-555)

Category 01

December 1966 Brief 66-10696

NASA TECH BRIEF

Low Rate Flow Switch Can Be Used for Gas or Liquid



The problem:

To construct a reliable flow switch which is operable at low flow rates. This is used for detecting the flow of a water coolant in a vacuum deposition apparatus. Coolant monitoring is imperative in many semi-automatic machines used in processing production items. The switch should be convenient and simple to use, trouble free, and capable of use with either gas or liquid.

The solution:

A flow switch utilizing one more reed switches that are actuated by a sliding magnet.

How it's done:

The switch elements are incorporated in a conduit in such a manner that a slight movement of fluid in the conduit causes the sliding magnet to move into a position relative to the reed switch assembly. When

(continued overleaf)

this occurs, the magnetic flux path reacts with the switch assembly and closes the switching circuit. The magnet is coated with a low-friction material such as Teflon. The reed switches are set into place by set-screws.

A return line connects the low pressure side of the input to the output line in such a way that any input forces the magnet upward. The orifice is designed so that any liquid remaining in the chamber above the magnet is bypassed out the return line. Return of the magnet downward is accomplished by gravity. An external indicator circuit consisting of a battery and lamp is closed when the magnet is moved under a critical point.

This system does not require pressure sufficient to close a spring bias. The only forces involved are the very low coefficient of friction between the Teflon coated magnet and the conduit in which it moves and lifting the magnet against gravity.

Notes:

1. Although in practice the switch body was made of lucite, any other nonmagnetic material can be used.
2. Models have been constructed which were able to sense flow ranges as low as 4.0 cc per second.
3. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference; B66-10696

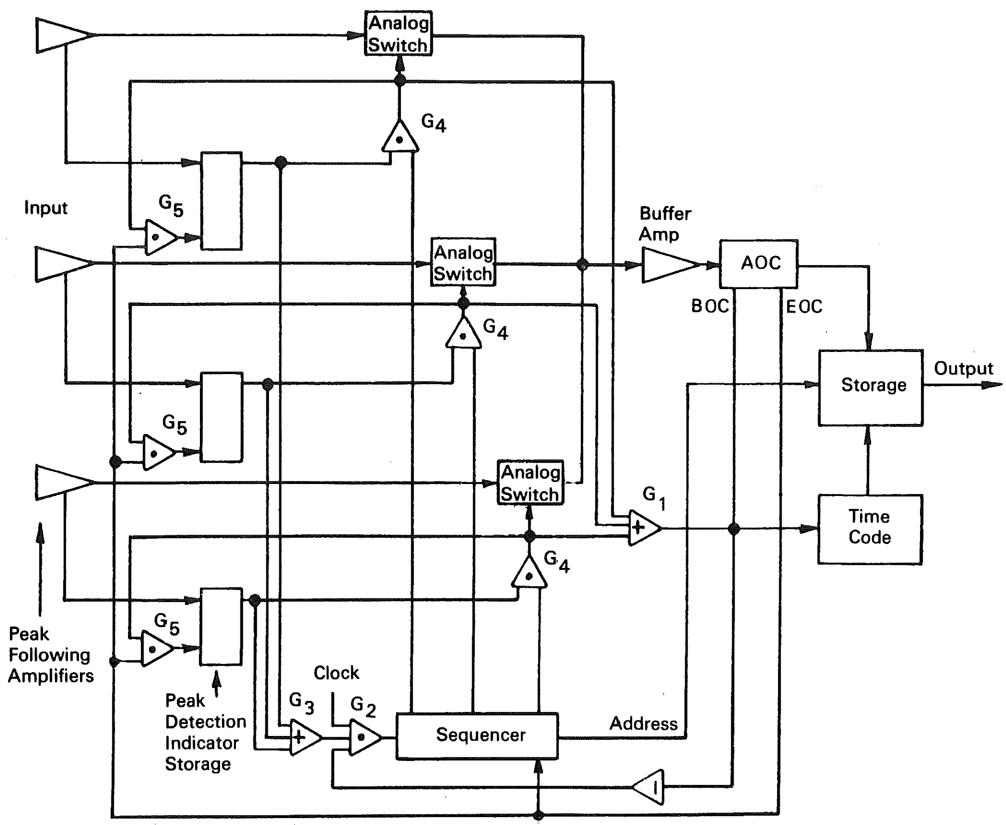
Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: E. T. Bates, Jr.
(JPL-867)

NASA TECH BRIEF

Monitoring System Determines Amplitude and Time of Vibration Channel



The problem:

To devise a method for the continuous sampling and processing of several vibration channels in order to determine the amplitude and location in time of each peak of every channel. The channels contain vibration data of widely varied frequencies with the relative order of these frequencies generally known. Prior art sampled all channels at the same rate in a continuous, fixed sequence mode. This method was in many instances too time consuming.

The solution:

Coordinate the higher frequency channels with the lower order addresses of a sequencing system and reset this to its initial condition upon completion of each conversion.

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How it's done:

The processing scheme includes an analog-type peak following amplifier for each channel, an analog commutator, a digital address control or sequencing device that is adaptive relative to the behavior of each channel, an analog-to-digital converter, and a time code generator common to all channels. An analysis of the timing involved in the worst case situation when (1) a peak occurs on a channel right after that particular channel was completed in the continuous mode and (2) when a peak occurs simultaneously on each channel, and all channels contain their outer limit frequencies in the adaptive mode, reveals the following:

The total time required to reach all channels in a continuous mode is n^2t and for the adaptive mode, where the address is returned to zero between samples and the inputs are assigned addresses inverse to the assumed frequencies, the total time is $(1+2+3+4+5+6+\ldots n)t$. The relationship between the two modes is then n^2t/n to $n+1/2(t)$ where n is the number of channels and t is the system clock period.

The outputs from the preprocessing analog amplifiers of which there are one per channel, are sampled and converted to digital numbers for storage, recording and/or further processing. The sampling system is adaptive in a manner such that all peaks on all channels are processed. The bandwidths of the various channels with the relative orders of their frequencies generally known are then located in this order.

Notes:

1. This method is applicable to environmental testing and to space- or aircraft-borne vibration monitoring devices requiring a large number of channels. It is conceivable that this system could be used in aircraft development and in commercial aircraft as a monitoring system for determining safe operating limits.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Jet Propulsion Laboratory
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B66-10699

Patent status:

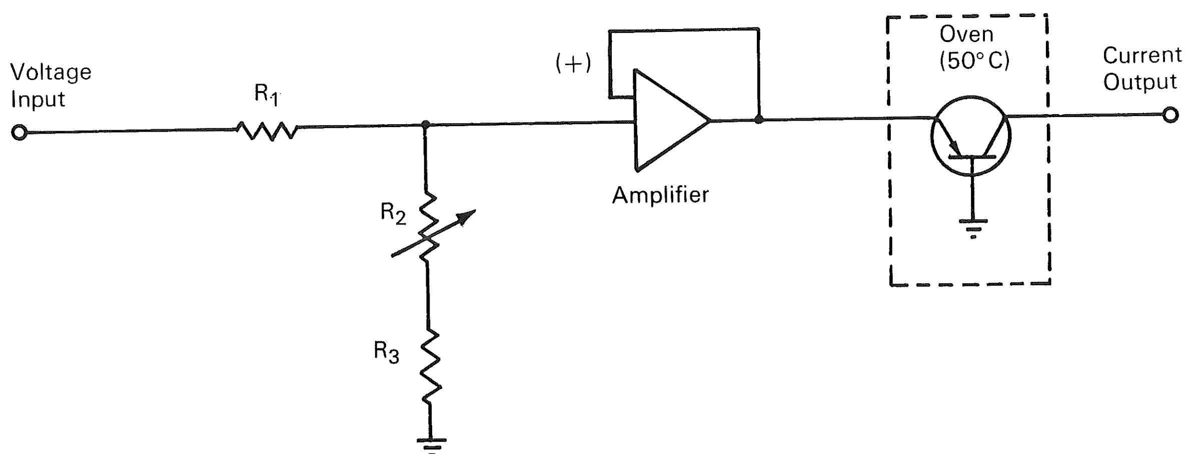
No patent action is contemplated by NASA.

Source: Tage O. Anderson
(JPL-879)

December 1966 Brief 66-10706

AEC-NASA TECH BRIEF

Microcurrent Generator Produces Electrical Currents Accurately between 10^{-11} Ampere to 10^{-3} Ampere



The problem:

To test low current devices such as ion chambers a current generator was needed to accurately simulate currents in the range of 10^{-11} ampere to 10^{-3} ampere.

The solution:

An electronic circuit design that uses operational amplifiers, current dividers and a transistor such that the current output equals antilog (V_{input}/K), where K is determined by circuit parameters.

How it's done:

The microcurrent generator shown has the required characteristics, i.e., $V_{in} = K \log V_{out}$. The voltage divider (R_2) is used to set the value of K. For this particular circuitry to produce a current change of one decade, the voltage at the output of the operational amplifier must change by approximately 60 millivolts. Stabilizing the transistor by placing it in a a temperature controlled oven at 50°C provides a low current limitation of the circuit of 10^{-10} ampere. The circuit is adjusted so that each time the input voltage changes 2 volts in range, a change in current of one decade is produced. For example: a change from 2 to 4 volts provides a current change of one decade; a change of 2 to 8 volts results in a current change of 3 decades, etc.

Notes:

1. For the circuit shown:

$$I_{out} = 10^{-11} \text{ antilog } (V_{in}/2 + 2)$$

2. Compensation networks have been devised to improve the accuracy at the lower current levels.
3. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   AEC–NASA Space Nuclear Propulsion Office
   U.S. Atomic Energy Commission
   Washington, D.C. 20545
   Reference: B66-10706

(continued overleaf)

Patent status:

No patent action is contemplated by AEC or NASA.

Source: J. Wilson
of Westinghouse Astronuclear Laboratory
under contract to
AEC–NASA Space Nuclear Propulsion Office
(NU-0087)

December 1966 Brief 66-10709

AEC-NASA TECH BRIEF

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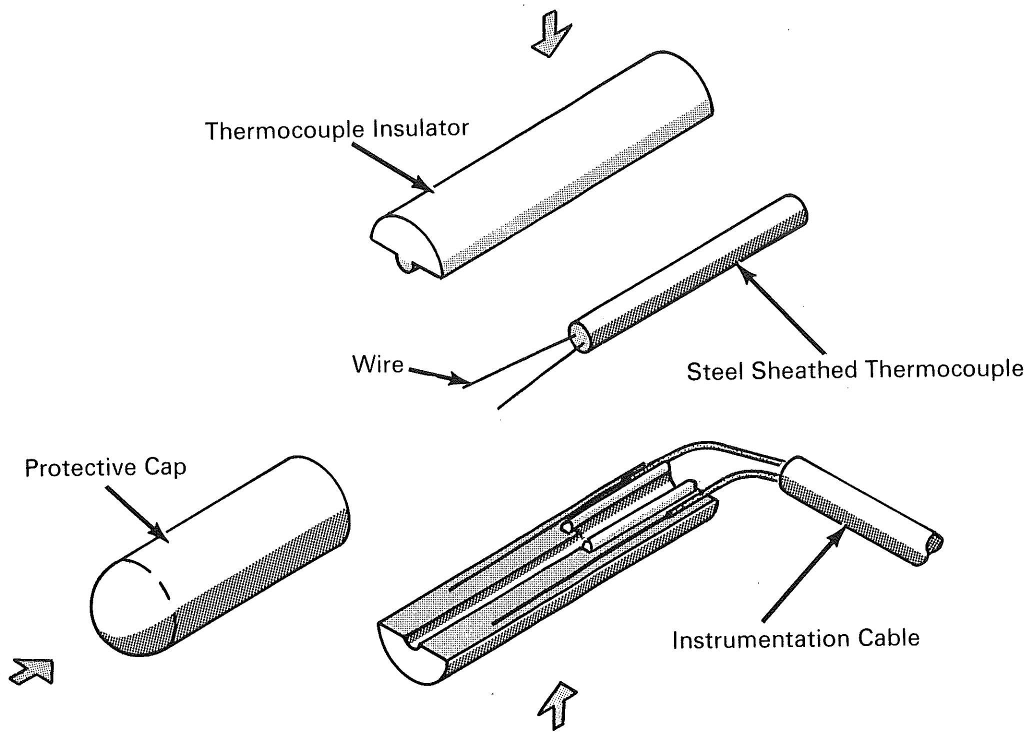
Thermocouple–Flexible Cable Connector Insulator Is Highly Reliable



The problem:

To design highly reliable thermocouple connectors for use in test operations. A commercially available steel sheath type of thermocouple was furnished with the flexible instrumentation cable attached. As supplied the connection of the instrumentation cable leads to the thermocouple lead-in wires at the end of the steel sheath was insulated by epoxy potting. This connection was highly unreliable because of the electrical shorts that developed. A more reliable type of connection and insulator was required.

The solution:

A plastic (polycarbonate) insulator that is molded in half sections, assembled mechanically, and eliminates electrical shorting.

How it's done:

The thermocouple insulator and protective cap enclose the steel sheathed thermocouple which contains two wire leads. The steel sheathed thermocouple with its bare wire leads is placed in one of the insulator halves so that the wires are separated. The instrumentation cable wire leads are soldered or laid

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against the thermocouple bare wire leads and the other insulator half is mated together. The protective cap is press fitted over the insulator halves, and the unit is then dipped in methylene chloride thus bonding the entire unit together.

Note:

Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
AEC–NASA Space Nuclear Propulsion Office
U.S. Atomic Energy Commission
Washington, D.C. 20545
Reference: B66-10709

Patent status:

No patent action is contemplated by AEC or NASA.

Source: C. M. Gracey
of Aerojet-General Corporation
under contract to
AEC–NASA Space Nuclear Propulsion Office
(NU-0082)